Example Measurements of the Moisture Content of Biomass

Perfectly dry biomass would be a boon for stove testing (and for use by cooks around the world) but it is rarely available – therefore we should at least know what our moisture content is so that we can estimate how much of our energy we are using up boiling it, instead of having it available to work with. After seeing Tom Miles' post on the standard procedure for microwave drying of wood (I thought that I developed this in my kitchen a few years ago!):
http://gasifiers.bioenergylists.org/milesmccontent
Here I dig up some of my own data – I need to know moisture content for preliminary cooking stove Water Boiling Tests (WBT), and it is also one of the major variables when operating biomass gasifiers. Understanding water *re-uptake* by biomass is important as well – whether it is due to changes in the weather, it occurs after we open a new bag of wood pellets to be used for baseline testing, we needed to move our supply from one place to another, or because we have gone to all the trouble of using producer gas to dry fuel but don't have time to burn/gasify it for a few days.

EMC and Measurement Methods
The equilibrium moisture content (EMC) is just the amount of water in biomass that has had enough time in its constant temperature and humidity environment, so that it is no longer taking up or getting rid water. There are many websites to determine your EMC, and I use this one:
http://www.woodbin.com/ref/wood/emc.htm

There all kinds of electronic tools for making measurement, using a variety of physical principles, but I prefer to use my ordinary kitchen microwave and toaster oven (perhaps the latter is slightly easier to find in the field) because I trust these much more – this method doesn't care what size my biomass comes in or how high the moisture level is (and I don't have to take into account wood species!). Any weighing scale with the right capacity and precision will work, you just have to size the batch that you are drying. With the arrival of very cheap imported goods, you can now get a small battery powered "postal scale" for a price we would have died for a few years ago
http://search.harborfreight.com/cpisearch/web/search.do?keyword=digital+scale
The larger $20 one for example has a capacity of 5000 grams and a resolution of 1 gram – your local office supply store will have these for just a modicum more. And don't forget that people were making accurate measurements long before the invention of *digital* or *electricity*, as long as there was something to calibrate themselves with:
http://www.instructables.com/id/Pretty_Good_Postal_Scale_from_Old_CDs/
but as with any testing make sure you understand the capabilities of your tools and procedure, and occasionally repeat your measurements so that you have the right to trust them (here is a good article that pertains to digital scales in particular: http://www.tutelman.com/golf/measure/digitalScaleTest.php?ref=).

Experiments
The temperature and humidity here near foggy San Francisco were about 10 °C and 50% RH outdoors, but I work indoors and my raw materials came from various parts of the house and shop so the predicted 9-10% RH does not really mean that much, and anyway my interest was in the measurement process not the actual values. The Figure 1 shows moisture content results for several samples, with two drying methods:

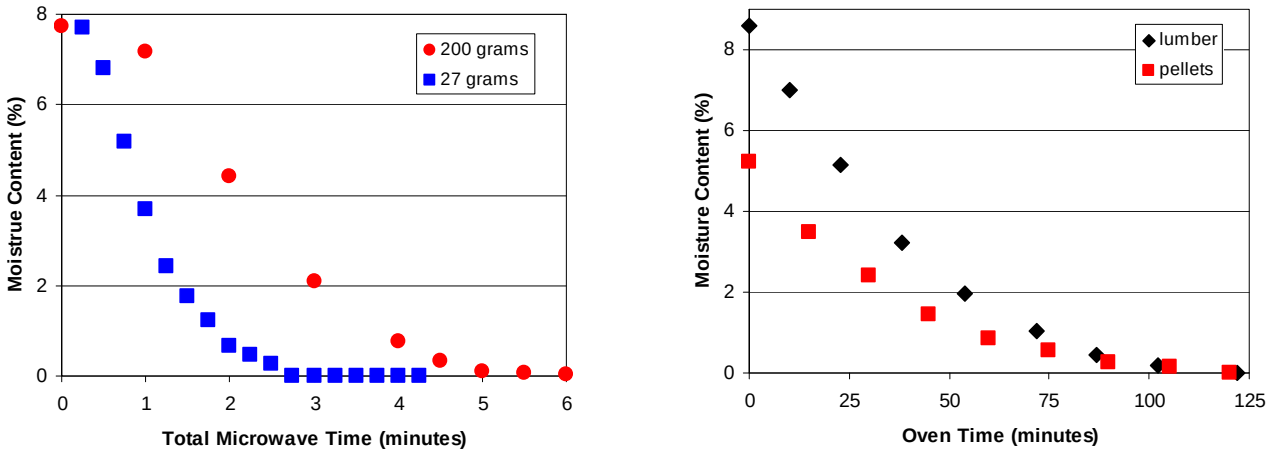

Figure 1. Moisture content during a) microwave drying of lumber for stove testing, and b) using a portable oven (80 ^{o}C).

We see that the microwave technique is of course very fast (but follow the procedure – no pulses longer than 30 seconds at the end) and the drying time depends on the sample mass, while when using an oven the time is somewhat size independent. For any heat source there will be critical variables which will impact your measurements, including sample mass, initial moisture content, ventilation characteristics, biomass dimensions, etc.

Biomass Moisture Absorption

Just as wet biomass slowly approaches the EMC by **losing water**, dried biomass **absorbs moisture** from the air to try and reach the EMC. Because of the small dimensions, this can happen relatively quickly for our typical biomass. Figure 2 shows the nature of this re-absorption process for hardwood fuel pellets (sold for northern North American residential heating pellet stoves) after they have been fully dried. This experiment took place during a mostly rainy period – the details for this example are not important because every situation will be different.

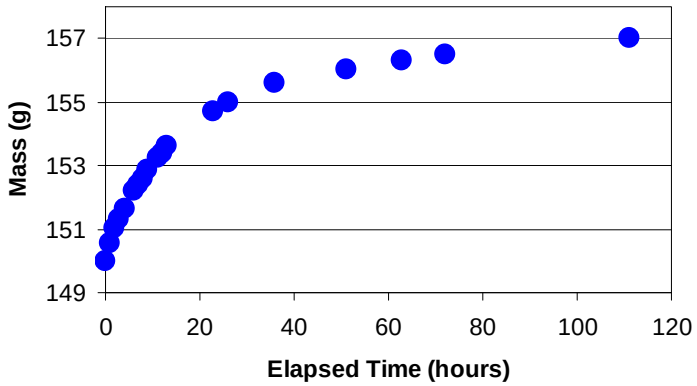

Figure 2. Re-absorption of moisture by dry hardwood pellets.

The majority of the re-absorption takes place in the first day, but it will take the biomass several days to reach the indoor EMC - and the process seems long enough that short term changes in the temperature and humidity did not impact the results (i.e. we see that the MC changes smoothly despite the fluctuating

weather conditions). Since commercial microwave drying of lumber is on the horizon, there is an interest in more extensive measurements than demonstrated here - a technical good article on sorption characteristics is here:
http://www.unitbv.ro/il/iufro2003modific/postiufro/Poster%20session/Leiker%20-%20Aurich.pdf

Impact of Fuel Moisture Content

I was testing the performance of the commercial WoodGas (an older Model LE) TLUD gasifier cooking stove on a scale and got the results shown in Figure 3 for wood pellets with two different moisture contents:

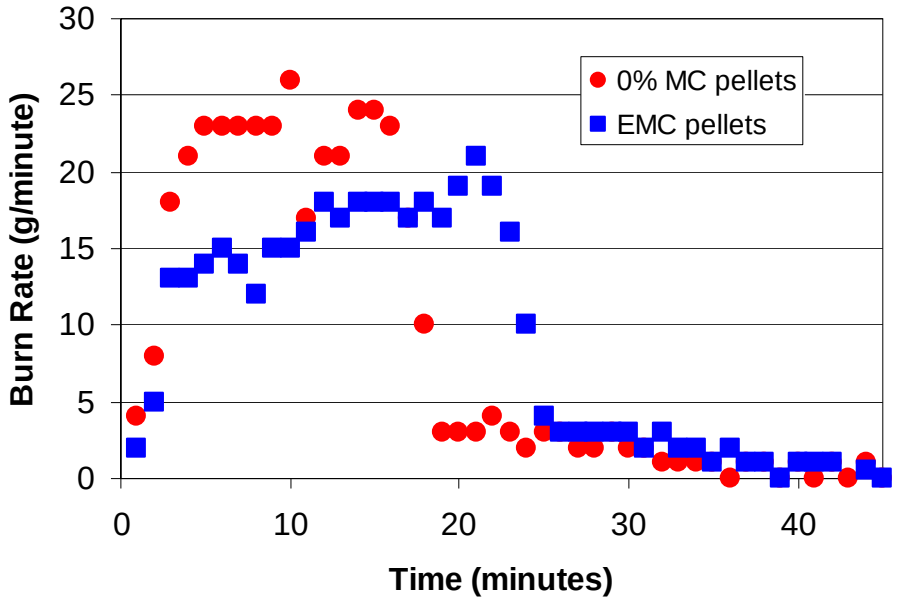

Figure 3. WoodGas stove performance with pellets at different moisture contents.

Without trying here to over analyze, we see that the burn rate is higher and reaches its peak value faster for dry pellets, but of course then the point at which pyrolysis is complete arrives sooner; and for both trials the transition to the much lower firepower "charcoal phase" is very abrupt. Since the burn rate is related to the firepower, reaching a high (and stable – more so with 0% MC pellets) value will tend to be favored by cooks.

When using a different "biomass appliance" such as a gasifier, the impact of biomass moisture content on operation will manifest itself differently – wood pellets made from sawdust may expand, the mechanical particle flow characteristics will change, stability of operation could be altered, water collection in vessels and lines may be more obvious, the quality of gas can vary significantly, and internal combustion engine performance differences will be important.

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