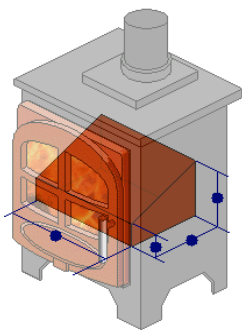


"While philosophy has lent her aid towards the perfection of almost every other art, the builder of fire-places, and the maker of grates, have been left in a great measure without her assistance."

For all the advances since the great fireplace designer William Flavel wrote those words in 1840, there is still no practical way to predict the performance of a solid fuel appliance, for every log, lump of coal, chimney and refuelling cycle is different. Some approximate methods are...

1: SIMPLE VOLUMETRIC ANALYSIS



Given the *actual* (not *total*) firebox volume (in m³) available to be filled with fuel inside an appliance, the total output in kW/hr is roughly predicted from:

(Volume x FuelBulk x PotentialHeat x Efficiency x ProportionConsumedPerCycle) / RefuelHours

With typical efficiency as 0.65, the ProportionConsumedPerCycle as 0.7, and combining FuelBulk and PotentialHeat into one 'BulkPotential' factor (see Table 2) this becomes:

(Volume x BulkPotential x 0.455) / RefuelHours, as in Table 1

| TABLE 1 Approx. expected stove output per m ³ of fuel | Refuel interval, Hrs | kW output per m ³ |
|---|----------------------|------------------------------|
| Wood Logs | 0.75 | 1154 |
| Wood Logs | 1.5 | 577 |
| Wood Logs | 3 | 288 |
| Anthracite | 4 | 865 |
| Anthracite | 12 | 288 |
| Peat Briquettes | 4 | 427 |
| Lignite | 4 | 444 |
| Bituminous Coal | 4 | 676 |
| Multi-fuel <i>quick guess</i> | | 400 |

2: FLUE LOSS

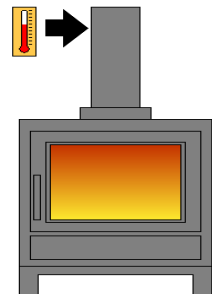
This method finds the actual burning rate and approximates the *loss of efficiency* by measuring the gases exiting the appliance.

PROCEDURE:

1. Light the fire and allow to burn down to the ordinary refuelling level.
2. Refuel the fire in the ordinary way, filling it back to the normal fuel level.
3. With constant draught (say, 12Pa) leave the appliance to run unaltered for the normal refuel cycle (say, 1.5 hours).
4. Efficiency will vary across a burning cycle, so **just taking a single reading is valueless** - the flue gases and room temperature must be noted at regular intervals (say, every 5 minutes) across an entire cycle from fuelling to refuelling.
5. At the end of the cycle, refuel the appliance to its level at the start of the cycle. Note the mass of fuel required.
6. Add together all the readings and find the mean values over the the cycle. Use the mean values to find the efficiency by one of the methods below.

ESTIMATING EFFICIENCY FROM TEMPERATURE

A rough guide to efficiency can be found just from measuring the flue temperature. This is moderately accurate (\pm c15 points) for well-made wood-fuelled stoves with a correct ratio of fuel to air, but can become exceedingly over-optimistic for poorly-sealed appliances. Given the *mean* flue temperature over a fuelling cycle...



Efficiency (as a percentage) is approximated by **100 - ((MeanFlueTemp - MeanRoomTemp) / 13)**

EFFICIENCY BY GAS ANALYSIS

This method analyses gases leaving the appliance and thereby gives an indication of how efficiently they have burned.

Manufacturers of gas analysis instruments with the 10000ppm+ CO reading necessary for solid fuels include Crowcon (www.crowcon.com), Bacharach (www.bacharach-inc.com), Testo (www.testo.com), Dwyer (www.dwyer-inst.com) and ABB (www.abb.com). Some of these instruments can carry out an efficiency calculation automatically, but check that it has been set for the *exact* fuel being used; wrong fuel factor = wildly wrong result. Equally, it is pointless to take a single measure, readings must be averaged over an entire fuelling cycle.

Given the percentage of carbon dioxide (CO₂) in the exiting flue gas, Siegert's formula (accurate \pm c5 points) gives the efficiency from: **100 - ((MeanFlueTemp - MeanRoomTemp) x (A1 / CO₂%))** (for the 'A1' factor see Table 2)

AND THE ANSWER IS...

Hourly Burning Rate is given from **(1/RefuelHours) x RefillMass**

Total output (in kW) is given from **PotentialHeat x Efficiency x HourlyRate** (see Table 2)

Water Output (in kW) from boilers is: **(4.18 x MeanWaterFlowratekg/hr x (MeanWaterOutletTemp°C - MeanWaterInletTemp°C)) / 3600**

so that room output of a boiler appliance is **TotalOutput - WaterOutput**

| TABLE 2 Typical properties of solid fuels, as supplied | Anthracite | Hard Coke | Soft Coke | Hard Briquettes | Bituminous Coal | Lignite Briquettes | Peat Briquettes | Dry Wood Logs | Wood Pellets | Dry Baled Wheat Straw |
|---|------------|-----------|-----------|-----------------|-----------------|--------------------|-----------------|---------------|--------------|-----------------------|
| Moisture % | 4.5 | 8.5 | 8.5 | 12 | 7.5 | 18.5 | 11.5 | 18.5 | 5 | 15 |
| Ash % | 8.5 | 9.5 | 7 | 8 | 5 | 7.5 | 5 | 1 | 0.15 | 4 |
| Volatiles % | 8.5 | 1.5 | 9 | 11 | 32.5 | 56.5 | 68 | 84 | 80 | 72 |
| Siegert A1 number | 0.683 | 0.290 | 0.290 | 0.683 | 0.672 | 1 | 0.7 | 0.650 | 0.650 | |
| Heat content kJ/kg | 31155 | 27050 | 28000 | 29500 | 26750 | 19500 | 18050 | 18500 | 18600 | 16000 |
| Potential Heat kW/kg | 8.65 | 7.51 | 7.78 | 8.19 | 7.43 | 5.42 | 5.01 | 5.14 | 5.17 | 4.44 |