Physics for stovies

Glyn Hughes explains what's really happening inside your stove

I've got a solid fuel stove in my house. It's a perfectly ordinary one, and it works like this: I put one shovelful of anthracite on it in the morning, and it burns, untouched, all day and all night, and all the next morning, when I put another shovelful of fuel on. That's it. The room stays nice and warm, but never gets too hot and it never smokes out into the room. If the weather's really cold, I might have to top it up in the afternoon, but, generally, I only touch it once a day, and never relight it all winter long. I understand that stoves in boats don't quite manage to do all this.

I'm the information officer of The Solid Fuel Technology Institute at www.soliftec.com, and I'm going to have a go at explaining what's going on, and how you might well halve your fuel consumption, make your craft safer, cosier and generally make the whole world a brighter and cheerier place.

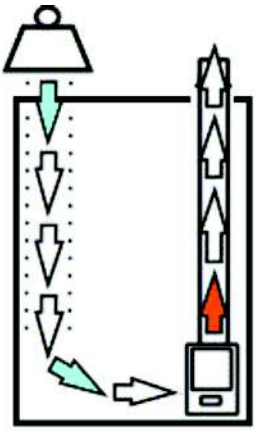
It is easy to assume that a chimney, or rather the hole up the inside of a chimney (the flue) is a sort of duct to let waste gas and smoke out of a stove. But it does't work like that: stoves only work because they lose a certain about of heat into the chimney. Although a chimney appears to 'suck' and smoke appears to naturally rise, it is more accurate to think of the weight of dense air outside a stove pushing down to force the hotter, lighter, waste gases out up the flue. This 'Chimney Effect' generates the draught, the very tiny difference in pressure inside and outside the flue.

That's why you can't burn a log out of doors. Go on try it! A single log or lump of coal just won't burn in still air. But if you have a pile of logs then there is a little chimney effect between the logs, so bonfires will burn fine.

The hotter the inside of the chimney (and the taller it is) the more vigorously the smoke and gases inside rise, and the more vigorously fresh air is pulled in over the fuel, making it burn. Stove chimneys on boats are commonly very short and aren't insulated at all, which means that they develop very poor draught indeed. Flue draught is measured in Pascals (Pa). A good house chimney will get hot enough, around 250°C inside, to develop about 12 Pa. A really well-made insulated boat chimney might manage 6 Pa. An uninsulated boat chimney will only get to about 90°C and so suck at only around 1 Pa. Stoves are pretty much all designed to operate at 12 Pa. If the inside of the chimney isn't hot enough, and doesn't generate enough draught, three big problems start to happen.

First – fumes.
The fumes from burning wood or coal-type products are extremely poisonous. They contain carbon monoxide at around 100 times the concentration found in a gas fire. Poor draught means that these dangerous gases aren't likely to be properly pulled out of the cabin.

Second – damp.
Wood and coal, even when they seem very dry, contain an astonishing amount of water locked up inside their structure. As they burn, this is given up as steam, which, if the chimney doesn't get up above around 160°C, will condense on the insides of the flue. This, along with acids from the fuel, forms a tar that causes rapid rusting, even of ordinary stainless steels, and can even build up to block the flue, leading to the risk of carbon monoxide leaking out into the cabin.

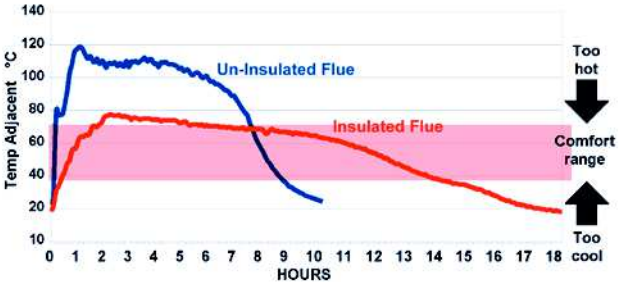


The chimney effect,

Third – lack of combustion.
Without adequate draught, fuel just won't burn properly. It will be slow to light and you won't be able to burn the usual stove fuels like anthracite. I'm more than a bit worried that, because of poor chimney draught, many boatyards are reduced to selling petroleum coke. This is manufactured from oil and intended for use in the cement-making industry. 'Petcoke' will burn on almost anything, but it is dangerously high in poisonous and corrosive sulphur (you can smell it!), as well as being horrendously expensive.

So, insulate your chimney and all will be well. But, surely, putting insulation around the flue pipe inside the cabin means you'll get less heat from the pipe and have to use more fuel? Strange to tell, the opposite is the case. If you have an uninsulated chimney, you'll have poor draught. That will mean that if you turn the stove down below a certain level, the chimney will cool even more, all draught will be lost and the fire will go out. You won't be able to keep a low steady glow, but will have to have the fire burning far too hot just to keep it alight. You might just be familiar with the baking hot cabin, which smells of sulphur? Furthermore, with poor flue draught, the stove won't pull air in forcefully enough for the fire to burn efficiently. It will actually give out less heat per lump.

In laboratory tests, we used a Portway boat stove with 1½ metres of 4-inch diameter flue. The graph below shows heat output using one single filling of fuel, untouched and unadjusted and left to burn for as long as I could get it to. The area under each line indicates the total heat given out. We found that the stove with the insulated pipe could burn for roughly twice as long as the uninsulated one. The total amount of heat given out by stove + pipe was roughly the same – adding insulation hadn't reduced the net heat volume at all. But, because it couldn't be controlled as efficiently, the uninsulated stove spent most of its time giving out far more heat than was needed.



The end result
insulate the chimney and you might well halve your fuel consumption. Oh, and you should have a stove which lights quicker, burns better, doesn't smell, smoke or make tar, will burn logs cleanly and be able to use a full range of fuels, including the inexpensive and the clean ones. It might even have a window which stays a lot cleaner.

Of course it's all very well quoting bits of physics and doing tests under careful lab conditions, but that isn't always what happens in the real world. Where I could really do with some help is by real people out there letting me know what happens in practice. I would also offer a word of caution: it is not simply a matter of insulating an existing chimney. If this is done, the flue and the top collar will both get hotter than before. Lengthways expansion of the flue must also be taken into account, together with any increased danger of setting fire to the cabin lining.

Editor's note: Please let me have your experiences of solid fuel stoves - both positive and negative - as well as your tips and advice to share with Glyn and NABO News readers