

ALL YOU'VE EVER NEEDED TO KNOW ABOUT STEAM BUT WERE AFRAID TO ASK

William Brubaker
Wellons, Inc.
Sherwood, Oregon

Peter Neild gave us an excellent insight into the use of thermo fluid heating. Today I shall give you a somewhat parallel view of steam systems, not a comparison with thermo fluid heating but a parallel description.

We all know that fire has been around a long time, and for that matter so has water, and naturally, steam. For so long, in fact, that you probably think it's a pretty dull subject, so we all take steam pretty well for granted. Au contraire! Steam is a fascinating substance.

Steam has some amazing powers!

1. It can heat things for us.
2. It can do work for us--move locomotives, battleships, turn turbines to generate electricity.
3. It can provide humidity to otherwise dry environments.
4. It can be used as a pump to move fluids or gases.
5. It can move itself for great distances.
6. It can be used to alert us, as with a whistle.
7. It can extinguish fires.
8. It can be used as a cleansing agent.
9. It can be used as a sterilizer.
10. It can be used to produce distilled water, (water with zero impurities).
11. It also is odorless.

First though, let's define what steam is. Steam is water that has been boiled into a vapor. It takes very little heat energy to raise the temperature of water to reach its boiling point. Say you put a pint of 32°F water in a pan on the stove. A pint of water weighs approximately 1 pound. (You remember. . . "a pint's a pound the world around.")

You have all heard of the BTU of heat energy (British Thermal Unit), it takes one BTU to raise one pound of water one degree Fahrenheit. So if the water in the pan on the stove is put in at 32°F, it will then require 180 BTU's to bring the water to boiling temperature, or 212°F. Now, no matter how hot the stove burner is, the water will get no hotter than 212°F. As this pound of water boils at 212°F, heat energy is being added to change it to steam. When the last of the pound of water has been vaporized to steam, the stove will have added 970 BTU's to that pound of water to furnish the energy to make what we call a pound of steam. A pound of steam is merely a pound of water that has been transformed to steam. Sooner or later, this pound of steam will be converted back to a pound of water. And that is where the magic of steam comes into play in our dry kilns.

Many people confuse this pound of steam with the term "pounds per square inch of pressure," but never really quite understand what is meant by pounds of steam/hour. But remember, when we speak of a pound of steam, we're speaking merely of its weight before it was boiled. So, a boiler which can boil 10,000 pounds of water in one hour is rated at 10,000 pounds per hour. To further confuse the issue, we sometimes speak of Boiler Horse Power (BHP) when we refer to a boiler's capacity. One BHP is equal to 34.5 pounds per hour of steam, so 10,000 pounds per hour of steam is the same as 289.9 BHP.

Remember, we used only 180 BTU's of energy to bring a pound of water to boiling. And we had to add another 970 BTU's to vaporize it to steam. 84.3% of our energy was consumed as the heat of vaporization. That magic property of steam makes possible all the marvelous things it can do.

But we should digress for a moment. Up till now, our steam has vaporized into the atmosphere out of our control. Next, it is necessary to harness the steam so we can direct its energies to do good things for us. I'm sure most of you have seen a pressure cooker in either your kitchen or your mother's. What does the pressure cooker do? It confines the steam in a fixed volume and, as you boil your pound of water, something else happens--the pressure inside begins to build up. As the pressure builds, something else happens--the temperature rises above 212°F for the first time. I must confess that I really don't know how much pressure the average pressure cooker operates on but let's say, for the sake of argument, that it makes steam at 15 pounds per square inch. At that pressure something else happens--our pound of water does not boil at 212°F, it boils at 250°F, and the temperature of the steam is now 250°F.

Inside the pressure cooker, just as in the open pan of water, we add heat to bring it to boiling. When it reaches 212°F inside, the steam rises and tries to escape, but it can't, so pressure begins to build. When it does, it exerts pressure not only on the cooker walls, but also on the surface of the water. So we have to add more energy to overcome this restraint. The temperature begins to rise as we meet our new boiling point, and when we reach 15 psi, our boiling point is 250°F.

Now something else happens. The pressure cooker has a regulator valve that relieves the pressure as it attempts to rise above 15 psi. If it did rise unchecked, the vessel would rupture and a very dangerous explosion could occur. If the regulator valve malfunctions and the pressure rises significantly beyond 15 psi, a safety pop-off valve will open to relieve internal pressures, much the same as with a boiler safety pop-off.

Incidentally, you may have heard the term "saturation temperature of steam." This is merely the temperature of the steam as it rises from the boiling water. The saturation temperature is a very orderly fact of nature. If water boils at a given pressure, it will produce steam at a precise known temperature. You may also have heard of "steam tables." This is not a table that keeps your food warm. It is a table of numbers that tells you all about the properties of steam as they relate to heat energy--such information I have excerpted for Table 1.

Table 1. Properties of Steam Relating to Heat Energy

psi PRESSURE	POINT (°F)	32° TO BOILING	VAPORIZATION	BTU'S
0	212°	180	970	1150
10	240°	208	952	1160
15	250°	218	945	1163
100	338°	309	880	1189
250	407°	380	821	1201
600	490°	476	727	1203
697	505°	494	707	1201
1000	545°	543	649	1192
2000	640°	679	452	1131
3191	705°	903	0	903

Remember these are the figures for saturated steam. I don't want to, but I should mention another type of steam--and that is superheated steam. With a boiler (and we must now switch our thinking from a pressure cooker), we can pipe the steam from the boiler and pass the piping back through the firebox and add still more heat energy. This now converts the saturated steam to superheated steam. Superheated steam is best used to do work for us such as turning steam turbines to generate electricity.

By the way, at this point I'd like to simplify what happens to steam in the dry kiln. The easiest way is to imagine a dry kiln as a boiler in reverse. In dry kiln applications, we are much better off to use saturated steam, even though its temperature is lower than superheated steam. Saturated steam transmits its heat more readily in the heating coils.

The reason I mention superheat at all is that there is another way to get superheat than with a superheater on a boiler, and it isn't necessarily good to have it at the dry kiln. If your mill has a boiler producing saturated steam at, say, 250 psi and you are using steam at your dry kilns at 100 psi (which has been reduced from 250 psi through a pressure reducing valve), the steam will be 407°F, not at the saturation temperature of 338°F for 100 psi steam. The steam retains its original temperature of 407°F, or put another way, it has 69°F of superheat. Further, if you use a steam spray to condition your lumber, the steam exits from your kiln at 0 psi (or atmospheric pressure where the saturation temperature is 212°F, or put another way, it has 195° of superheat.

Saturated steam has 100% relative humidity. It's like living in New Orleans on a hot muggy summer day. Superheated steam is extremely dry and very hot--like the Sahara Desert. A superheated steam spray has so much dry heat that the wet bulb becomes cooler, rather than warmer (which is what you're aiming for). It calls for more and more steam spray. The dry bulb temperature goes higher and higher. The wet bulb goes lower. All you've accomplished is to further check, split and stress your lumber. . . and use steam like there's no tomorrow.

How to solve this? The best method is to install a separate header to supply steam for the steam spray. The steam going into

this header is first reduced in pressure to 10 psi and then cooled down with water injection as close as possible to the saturation temperature for 10 psi steam of 240°F. Your lumber quality will improve immensely, your boiler will be loafing, your fuel bill will drop dramatically.

As I said at the beginning, steam is an amazing substance. It does two things extremely well: 1) it will do work for us (turn a turbine), and 2) it will do heating jobs for us. If we use these two features in tandem, you have what we call cogeneration. The steam enters the turbine, produces electrical energy, then proceeds to the kilns to provide heating energy to dry the lumber. After it does this, it turns back into water, ready to be re-cycled over and over. And in the wood products industry, this can give us complete energy independence.