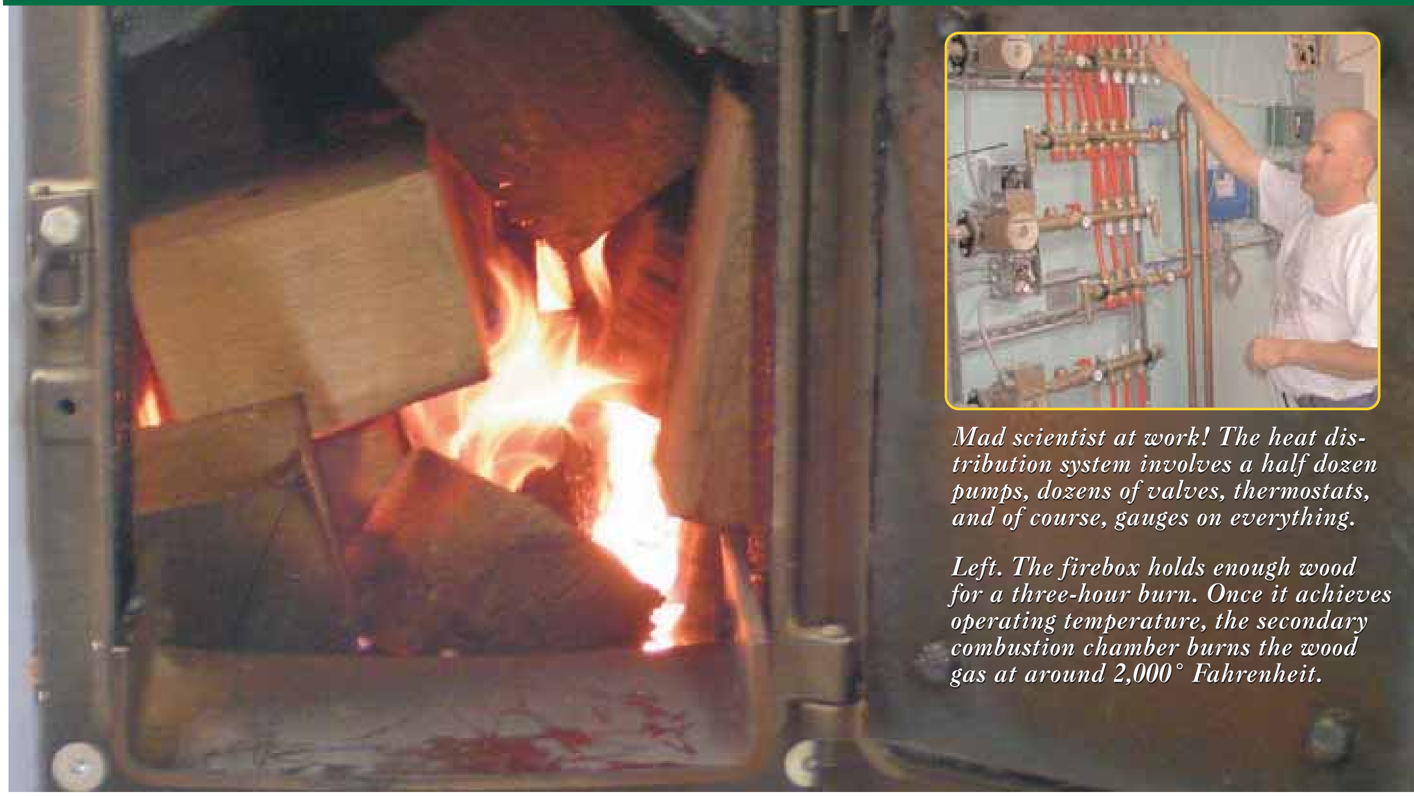

Mad scientist at work! The heat distribution system involves a half dozen pumps, dozens of valves, thermostats, and of course, gauges on everything.

Left. The firebox holds enough wood for a three-hour burn. Once it achieves operating temperature, the secondary combustion chamber burns the wood gas at around 2,000° Fahrenheit.

Tarm Solo 40
WOOD HEATER

Wood residues from logging operations, as well as sawmill slabs and edgings, present disposal challenges. Anyone who works with wood must wonder about better ways to use wood heat for space heating and hot water.

By Dave Boyt

Wood furnaces are thought to be smoky and inefficient during shutdown periods. This is because shutting them down when the heat is not needed involves starving them for air.

This inefficiency poses three problems.

First, unburned tars condense on the inside of the chimney as creosote, which chokes the chimney and poses the risk of a flu fire.

Second, the unburned gasses that do not condense on the chimney exit as smoke.

Third, low efficiency means burning more wood for the same amount of heat.

One solution is to design a stove that runs full-throttle throughout the burn cycle. The Tarm boiler reviewed here does this by passing the unburned gasses down through the coal bed to a second combustion chamber with a secondary air supply. In essence, it burns its own smoke. This type of stove is called a gasifier because it forces gasses down through the coal bed into a chamber where unburned gasses combine with additional air for complete combustion. In order to run at its most efficient rate, it dumps surplus heat into a water tank for thermal storage.

Travis Creswell has owned and operated a Tarm Solo 40 stove for two and a half years. His basement/workshop looks like something out of a 1950s mad scientist film. Papers with diagrams are stacked on just about every horizontal surface. The wall is lined with a maze of controls, gauges, pumps, valves, and tubing. As the owner of Ozark Solar, Travis installs wind and solar energy systems. He recalls his experience with conventional wood furnaces. “I have installed several different types of wood furnaces in homes, but was not impressed with the amount of wood they required, even with a well-built structure.”

When it came time to install a heating system in the house he was building for himself, he knew what he wanted. “There were two things I wanted in a system: radiant floor heating and wood heat. I checked on the Internet, and concluded that I would have to design and build my own wood gasification boiler. I had even started to buy some of the parts when I found this one." He continues, "I located Tarm on the Internet, and called the company. They told me about one of their stoves in a town about 20 miles away, and I went to see it." Travis purchased the Tarm Solo 40 model, which is rated at 140,000 BTUs per hour.

How It Works

The Tarm wood gasification furnace is far from the simple cast iron woodstoves that heat many homes. After the fire has been started, a fan forces the hot gasses downward through the fire, and into a refractory ceramic combustion chamber. According to Scott Nichols, part owner of Tarm U.S.A., the refractory chamber isolates gasses from a water jacket so they can maintain high temperatures. "The design heats the unburned wood gasses and secondary air to combustion temperatures and creates turbulence that mixes them and gives them time to burn before exiting the stove." The gasses leave the secondary refractory combustion chamber at 1,800 to 2,200° Fahrenheit. With no combustibles left to create creosote, the gasses then pass through tubes in the 54-gallon water jacket boiler before exiting up the flu at about 400°. According to Nichols, "the water jacket boiler is tested to 60 psi, and typically runs at 12 to 15 psi." The steel boiler body makes up the bulk of the stove's 1,160 pounds.

SPECS

Tarm Solo Plus 40 Wood Heater

Rated output	140,000 BTUs per hour
Dimensions	41 in. long x 25 in. wide x 54 in. high
Weight (dry)	1,160 lbs.
Firebox volume	5.35 cu. ft.
Max. firewood length	20 in.
Water jacket	54 gal., welded steel
Tested pressure	60 psi
Maximum pressure	30 psi
Heat transfer	closed loop water-to-water heat exchanger
Draft type	downdraft, forced draft
Catalytic converter	none
Secondary combustion	yes
Suggested price	$6,895
Options	natural gas or fuel oil backup, thermal storage tank

Contact: BAXI-HS Tarm U.S.A. PO Box 825, Lyme, NH 03768
800/782-9927 ▪ www.woodboilers.com

A pump circulates the hot water through a closed-loop system consisting of the boiler vessel and set of coils in a large water storage tank. While Tarm does have a tank available, Travis chose to build his own 1,200-gallon tank. From the tank, it is up to the owner to determine how to use the hot water. Travis runs water from the tank through a series of manifolds, pumps, and valves to distribute the warm water to heat the house with radiant floor heaters. A second copper coil in the tank is connected to his water heater for domestic use.

Even though it was 80° outside, Travis was building a fire to provide domestic hot water. “I build a fire about once a week in the summer,” he said. Even when the storage tank has cooled to 120°, it still heats up the water in the tank enough for comfortable showers. Lower than that, the electric heater kicks on, but it still uses less electricity than heating 50° groundwater straight out of the well.

The first order of business was to clean out the ashes. For this, Travis used a shop vacuum with a Heppa filter that keeps ash totally out of the air. Next, he removed the top of the furnace, exposing the eight fire tubes. Each tube had a metal baffle which he cleaned off before cleaning ash out of the tubes with a wire brush. “The baffles slow down the draft and add turbulence for better heat transfer.” Ash acts like insulation on the tubes, and reduces the efficiency of the unit.

Travis adjusts the temperature shut-off control. The dial indicators to the left are boiler pressure and boiler temperature.

Inside the heat storage tank, showing the heat exchange coils to the boiler (rear) and the domestic water heater (front).

Travis’s supply of firewood. It is not covered, so the moisture content is probably higher than optimal.

Application

Travis’s firewood supply comes from a local pallet company, mostly 4-inch by 6-inch oak and hickory cut-offs. “I bought a dump truck load for $200, and it looks like it will last me more than a year, and provide both heat and domestic hot water.” Travis estimates that he used about 1-1/2 cords last winter. He admits that the wood has more moisture in it than the furnace likes. “This stove is pretty sensitive to moisture. Even mixing green wood with dry wood cuts down its efficiency noticeably,” he said as he built the fire. “Right now, the water tank temperature is 83°. We’ll see how fast the stove brings it up.” Even though the system was just starting up, I had to look closely to see the faint wisp of smoke curling up from the 20-foot, double-wall metal flu.

While we waited for the fire to heat up the chamber, Travis lifted the Styrofoam cover off the top of the 1,250-gallon storage tank, revealing the two copper coils—one to the furnace, and the other to the domestic water heater. With a couple of seats and a water jet or two he would have one incredible Jacuzzi! “In the winter, the tank holds enough heat to warm the house for two or three days before I need to build another fire.” The tank stores 10,000 BTUs for every degree of temperature rise. “It takes about four hours of burn time to raise the temperature of the tank from 100° to 160°. I don’t like to go above 160°, because that could damage the Styrofoam insulation around the tank.”

“I pieced together the heat distribution system, largely out of pumps and pieces, materials I already had,” Travis told me. The radiant floor system has three separate circulation pumps—one for each of the two floors, plus one for the basement shop. The pumps circulate the hot water from the storage tank through a 4,000-foot labyrinth of plastic tubing in the floors, and back to the tank.

Operation

With the fire burning strong, Travis puts on some larger chunks of wood, closes the door and turns on the draft fan. Travis obviously loves his gadgets. He went over the list of gauges and valves. Among other things, he monitors the pressure in the coils, the temperature of the water exiting the stove, the temperature of the return water, the temper-

The baffle helps transfer heat from the exhaust tubes to the boiler. Travis cleans ash from the baffles and fire tubes every two or three firings.

ature of the storage tank, water flow through each loop of pipe for the floor heating system, and the flu temperature.

After about 30 minutes the water in the boiler body reached the 160° operating temperature, and the pump circulating the water to the tank coil kicked on. Opening the bottom door to view the gasifier, the system gave off the roaring sound of a natural gas furnace, and curls of flame circled around the ceramic plate. According to the manual, the gasification zone is 1,800 to 2,200° F. To demonstrate the heat in the gasification zone, Travis inserted a piece of copper tubing. When he pulled it out 20 seconds later, it was cherry-red hot. Adding another armload of wood, he told me, "The furnace will run for another three or four hours with no further attention."

Running relatively cold water from the storage tank heat exchanger into the steel boiler can cause

Travis Creswell's storage and distribution system. Note the number of gauges, pumps, and valves. Travis is meticulous in monitoring his furnace.

problems with metal expansion and thermal shock, so the unit uses a Termovar valve. This works much like the thermostat on the radiator of a car, mixing some hot water from the boiler with the water coming in from the water storage tank to keep the incoming water within 40° of the temperature of the water in the boiler. As the storage water temperature increases, the valve opens, allowing more water from the storage tank coils to circulate to the boiler. "The valve allows the stove to run more efficiently, and extends the life of the boiler," Nichols explained.

According to Travis, the system consumes about 60 watts for the fan, and 200 watts for the pump. He calculates that it takes about 8 kilowatt hours of electricity to get the storage tank up to temperature—less than $1.

Evaluation

Even after an hour and a half running wide open, the furnace housing never got more than slightly warm to the touch. Putting one hand on the outfeed and return tubes between the furnace and storage tank, I could feel a noticeable difference in temperature. According to the temperature gauges, the furnace was sending 185° water to the tank, and receiving 155° water back. This allowed us to make some rough calculations on output. According to Travis, the pump circulates water at about 10 gallons per minute, which translates to 4,800 pounds of water per hour. Multiply that by a 30° temperature difference and the stove is putting out 160,000 BTUs per hour. These rough calculations somewhat exceed the manufacturer's claim of 140,000 BTUs per hour.

Travis also made a rough estimate of the efficiency of the furnace. "They tout this as 80% efficient. I weighed the wood I put in for a couple of firings and measured the change of temperature of the water storage tank. I came up with an efficiency in the mid-60 percentile over an entire burn cycle, which isn't that bad, considering the wood still had quite a bit of moisture in it, and the burns were just about eight hours long, including startup and burndown." Wood generally has an average heating value of 6,000 BTUs per pound at 20% moisture content, but this goes down at higher moisture contents—partly because some of the weight is water, and partly because of the energy required to vaporize the moisture before the wood can burn.

The chimney is double-wall stainless steel. After two and a half years, there has been no noticeable build-up of creosote.

One indication of a fireplace's efficiency is the amount of tar and creosote buildup in the chimney. In addition to the fire hazard and choking the draft through the chimney, tar and creosote represent unburned fuel. Travis removed the cleanout cap from the bottom of his double-wall stainless steel chimney. Other than a light coating of ash, there was little indication that it had seen any use. "I check the chimney once a year, but haven't had to brush it out yet," he told me. Nichols says that he has burned seven cords of wood per year in his Tarm stove in the past six years, and still has not had to clean out his chimney.

According to Nichols, the stove is used for a variety of applications. "It is very flexible in that it uses water. In addition to space heating, it is used for heating outdoor pools, and we have had some interest from dry kiln operations." He pointed out that many owners use slab wood from sawmills to reduce the cost of the fuel. "We also have stoves that use corn and wood pellets. Some of these stoves are even used to heat water for car washes." Another option is a gas or oil burner that gives the owner the option of burning wood when it is practical to feed the stove, and run gas or oil when away from home for several days.

Are there any downsides to the Tarm boiler? A few. The first is that the furnace carries a hefty $6,895 price tag. Add another $6,000 for the water storage system, and you have a $13,000 investment. Even though this includes the heat exchangers in the boiler and water storage, it does not include the controls for the heat distribution system or the installation of the stove. Travis was able to do his own installation and already had many of the distribution components on hand, so this was not a major factor in his installation (other than his time). Another issue is the amount of space required for the 1,200-gallon water storage system. While he is extremely pleased with the performance of his system, Travis is still making modifications to the heat distribution system. "I decided to go this route, because I really wanted to set up a wood boiler," he says. "A conventional wood stove is fine for people who like to burn wood. I'm more interested in heating with wood." I suspect that this "mad scientist" also greatly enjoys monitoring and experimenting with the system. ■

Dave Boyt is a frequent contributing writer to Sawmill & Woodlot *magazine.*