Wood-burning stove

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A **wood-burning stove** (or **wood burner** or **log burner**) is a heating appliance capable of burning wood fuel and wood-derived biomass fuel, such as wood pellets. Generally the appliance consists of a solid metal (usually cast iron or steel) closed fire chamber, a fire brick base and an adjustable air control. The first wood burning stove was patented in Strasbourg in 1557, two centuries before the Industrial Revolution would make iron an inexpensive and common material, so such stoves were high end consumer items and only gradually spread in use.[1][a]

A 19th century example of a wood-burning stove

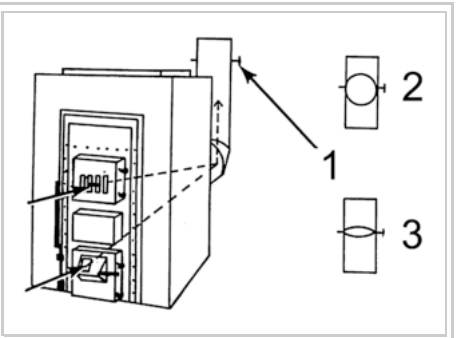
The stove is connected by ventilating stove pipes to a suitable chimney or flue, which will fill with hot combustion gases once the fuel is ignited. The chimney or flue gases must be hotter than the outside temperature to ensure combustion gases are drawn out of the fire chamber and up the chimney. Many wood-burning stoves are engineered such that they can be converted to multi-fuel stoves with the addition of a grate.

Contents

Operation

Air supply

Keeping the air flowing correctly through a wood-burning stove is essential for safe and efficient operation of the stove. Fresh air needs to enter the wood compartment to provide oxygen fuel for the fire; as the fire burns, the smoke must be allowed to rise through the stove pipes, and exit through the chimney. To regulate air flow, there are damper devices built into the stove, flue, and stove pipes.



A damper in a stove chimney flue (1) controls air supply by being set open (2) or closed (3).

By opening or closing the dampers, air flow can be increased or decreased, which can fan the fire in the wood compartment, or "dampen" it by restricting airflow and reducing the flames. The dampers can usually be accessed by turning a knob or a handle attached to the damper, found outside the stove or stovepipe. One of the uses of the dampers is to increase airflow into the wood compartment to raise flames and thus the temperature of the stove, to temporarily create a high heat for cooking.

High heating efficiencies on closed appliances can only be attained by controlling the supply of air to the fire chamber (operating the air control correctly). It is not recommended to leave the air control fully open, except when helping the chimney/flue heat up initially. A fully open air control will lead to more heat being sent straight up the chimney rather than into the room (which reduces efficiency). The biggest problem with leaving the air control fully open is “overfiring”. Overfiring is caused when too much heat is generated within the fire chamber, which will lead to warping, buckling and general damage to the stove and its internal components. Individual stoves will have their own quirks, so it is necessary to learn each new stove's settings.

Modern building techniques have created more airtight homes, forcing many stove manufacturers to recommend that their stoves be installed with outside air intake. Outside air ensures that stoves will run more efficiently, and also removes the need for cold air for the combustion process to pass through the living space, thus reducing "draughts", and improving comfort of the occupants. These designs are called "*room sealed stoves*" or "*external air supply stoves.*"

Fuel

Hardwood or softwood


Wood-burning stove heating a grocery store in Detroit (1922)

A large buy of Firewood is usually purchased in English-speaking countries in a quantity called a cord, measuring 128 cubic feet (3.6 m^3) (*a orderly 'tightly packed' stack* 4' high x 4' deep x 8' wide). Firewood is purchased by the cord, or by a fraction of a cord. Alternatively, it may be bought by the weight instead of by volume. The best fuels are oak wood, ash wood and beech wood, when well seasoned and cut small enough to fit into the grate of the stove.

When purchasing, cutting, or collecting firewood, it is crucial to be aware of the difference between hardwood and softwood. Both hardwood and softwood have the same energy content (by mass) and will provide similar energy outputs. However, the essential difference will be in the rate at which the fuel burns. Hardwoods derived from slow-growing broadleaf trees such as oak

and ash will burn at a slower rate, resulting in sustained output. Softwoods are derived from evergreen trees such as conifers, which are fast growing. They burn at a far faster rate. This faster rate of burning is accompanied by a slightly higher heat output. This is one reason why softwood pellets (for pellet stove) are popular [2] A disadvantage of softwood is that it creates more soot and other deposits such as creosote on the inside of the wood stove, chimney, and flue (which are themselves flammable partially burnt coating's and so a fire hazard) therefore requiring more frequent cleaning.[3]

Spencer woodstove in British bungalow at Pollibetta, India.

The difference in practical use is significant, and it is important to take it into account for both heating and cooking purposes. Hardwood is most often preferred for heating since it burns over a longer period, and produces a consistent temperature as it burns. Hardwood also creates a greater amount of ash as it burns, producing a bed of ash coals, which help retain heat as firewood burns.[4] Softwood, in contrast, is often preferred for cooking, since it burns quickly and produces high heat. Hardwood and softwood may be used together in a woodstove to accomplish both heating and cooking purposes by adding softwood on top of hardwood that is already lit. Softwoods are also the better woods for kindling a fire, since they generally burns hotter so aid drying and igniting larger woods present, but small slices of any type of wood can be used as kindling.

Moisture content

Dry wood produces more usable heat than wet wood, since the energy contained in evaporated water is lost up the chimney. Freshly cut wood (known as green lumber) has a high moisture content. Green wood of ash trees contains 35% moisture and green poplar contains 65% moisture. Apart from producing very low heat outputs, the flame temperature is also reduced. This causes unburned creosote. Creosote leaves the burning wood as a gas, and cools to a liquid in the chimney, where it collects on the interior. This oily liquid coats the inside of the chimney and stove pipes. It collects soot and other combustion particulates. A buildup can reduce the draft (airflow) in the chimney. The chimney soot can then be ignited by rising embers, causing a chimney fire.

For best results firewood should have a moisture content of less than 20%. The process of removing the excess moisture is called seasoning. Seasoning by air-drying the wood can take up to two years. Wood is dried in outdoor well-ventilated covered structures. With interest and usage of wood burners at an all-time high, some companies are now using large kilns to quickly dry their wood.

Multi-fuel models

Multi-fuel stove designs are common in the United Kingdom, Ireland and Europe. They burn solid fuels only, including wood, wood pellets, coal and peat. They are typically made of steel or cast iron. Some models are also boiler stoves, with an attached water tank to provide hot water, and they can also be connected to radiators to add heat to the house.

There are also stove models that can switch from wood fuel to oil or gas sources that are installed in the house to supply heat to a separate water boiler.[5] Stoves that readily convert to either oil or gas in addition to wood fuel have been manufactured in North America and Europe since the early 20th century, and are still manufactured. In some models, the oil or gas may fuel the stove through a pipe connection leading to a "pot

burner" in the rear of the firewood compartment in the stove.

Catalytic and non-catalytic stoves

As the temperature of the burning fuel/air mixture above the fire falls, the combustion process ceases. This means that the combustion gases often have both oxygen and fuel remaining uncombined in them. The combustion process can be continued at a much lower temperature in the presence of a catalyst. This reduces atmospheric pollution and may add to efficiency depending on the layout.

Catalytic wood stoves typically have a catalytic device built into the top of the stove, at the base of the stove pipe. The catalyst is held in a honeycomb metal lattice that re-ignites smoke from the fire as it rises to exit through the flue. In this way, the smoke itself becomes an additional source of fuel, which not only results in fewer emissions but improves heating efficiency.

> A catalyst will start burning the smoke coming from the fire when it has reached a temperature of between 350 and 600F. At this point, the catalyst is said to "light-off". In some models, the catalyst will begin to glow when the temperature rises above 1000F.[6]

It is possible though difficult to retrofit a catalytic converter to older stoves models, and retrofits rarely perform well. However, a drawback with catalytic converters is that (as when fitted to automobiles) they have a limited life before needing to be replaced, although new catalysts often last 5 – 10 years. More modern wood stoves are designed from the outset with an integral secondary combustion chamber. This mixes exhaust gases (smoke and particulates) with preheated fresh air and thus re-burns otherwise wasted fuel. The end result is similar, with much reduced emissions and increased fuel efficiency; stoves utilizing this design are often marketed as clean-burning stoves and exempted from smoke control regulations.[7]

Pyrolyzing stoves

In a conventional stove, when wood is added to a hot fire, a process of pyrolysis or destructive distillation begins. Gases (or volatiles) are evolved which are burned above the solid fuel. These are therefore the two distinct processes going on in most solid fuel appliances. Air has to be admitted both below the fuel and above the fuel to enable complete combustion and to maximize efficiency. The correct balance is difficult to achieve in practice and many wood-burning stoves only admit air above the fuel as a simplification. Often the volatiles are not completely burned resulting in energy loss, chimney tarring, and atmospheric pollution.

To overcome this, the pyrolyzing stove has been developed. The two processes go on in separate parts of the stove with separately controlled air supplies. Most stoves designed to burn wood pellets fall into this category.

Most pyrolyzing stoves regulate both fuel and air supply as opposed to controlling combustion of a mass of fuel by simple air regulation as in traditional stoves.

The pelleted fuel is typically introduced into the pyrolyzing chamber with a screw conveyor This leads to better and more efficient combustion of the fuel.

The technology is not actually new, it has been used for decades in industrial coal-fired boilers intended to burn coal with high volatile content.

Safety and pollution considerations

Safety

Correct air flow and ventilation are also critical to efficient and safe wood burning. Specific requirements will be laid down by the stove manufacturer. Legal requirements for new installations in the UK can be found in Building Regulations Approved Document J, Section 2, Table 1 "Air Supply to solid fuel appliances"[8]

Potbelly stove at the Museum of Appalachia

The safe operation of a wood-burning stove requires regular maintenance such as emptying ash pans (containers) beneath the wood grate. Routine cleaning of the stove pipes and chimney is also needed to prevent chimney fires. Creosote and soot gradually build up in stovepipes and chimneys. This could damage the chimney and spread fire to the surrounding structure, especially the roof. When soot blocks the airflow through the stove pipes or chimney, smoke can build up in the stove pipes and in the house through the stove.

The basic principle of controlling combustion by reducing the air supply means that very often there is a reduction zone/conditions within the stove. This means that carbon dioxide is often "reduced" to carbon monoxide, which is highly poisonous and must not be allowed to escape into the home. This can occur if the stove or chimney has not been cleaned or there is insufficient ventilation. Carbon monoxide detectors or alarms should always be installed according to manufacturers' recommendations where a wood stove is in use. Smoke detectors do not detect carbon monoxide.

Fuel accelerants such as coal, grease, oil, gasoline, kerosene, plastics, and so on, also must never be added to firewood in a wood stove, since the flames produced may easily overwhelm the wood compartment and stove pipes and create a house fire.

UK smoke control areas

Under the United Kingdom's Clean Air Act, local authorities may declare the whole or part of the district of the authority to be a smoke control area. It is an offence to emit smoke from a chimney of a building, from a furnace or from any fixed boiler if located in a designated smoke control area. It is also an offence to acquire an “unauthorized fuel” for use within a smoke control area unless it is used in an “exempt” appliance (“exempted” from the controls which generally apply in the smoke control area). The current maximum level of fine is £1,000 for each offence.

In order to comply with the Clean Air Act in "smoke control areas", an exempt appliance or fuel must be used.[9]

US pollution control requirements

The United States Clean Air Act requires that wood stoves be certified by the Environmental Protection Agency (EPA). These devices meet a particular emissions standard of no more than 7.5 grams per hour for non-catalytic wood stoves and 4.1 grams per hour for catalytic wood stoves.[10] Washington State has stricter requirements of a maximum of 4.5 grams per hour. However, the EPA has had no mandatory emission limits for pellet stoves, indoor or outdoor wood boilers, masonry stoves and certain types of wood stoves that are exempt from EPA regulation. EPA is developing new regulations and in 2015, these will begin to come into effect, establishing mandatory emission limits for almost all wood-burning appliances (fireplaces, chimeneas,

and some other special appliances will still be exempt).[11]

Justa stoves, rocket stoves and haybox stoves

In some places, such as the Caribbean, Central America and South America, many houses have wood-burning stoves that are used indoors without any means of proper ventilation. Smoke stays in the house, where it is breathed in by the residents, harming their health. Nearly 2 million people are killed each year by indoor air pollution caused by open-fire cooking, mostly women and children, according to the World Health Organization (WHO). The cutting of large amounts of firewood also endangers local forests and ecosystems.[12]

Non-governmental organizations (NGOs) such as Rotary International are actively assisting homeowners in constructing more fuel-efficient and safe wood-burning stoves. One design is called the Justa stove, Just stove, Ecostove, or La Estufa Justa. Justa stoves are made out of such materials as adobe, cement, and pumice, with chimneys. Other wood-burning stoves types are also being introduced to these communities, such as rocket stoves and haybox stoves. A rocket stove is up to 30% more fuel efficient than a Justa stove, but a small portable rocket stove (for cooking) does not have a chimney and is suitable for outdoor use only. Bigger rocket stoves are connected to chimney or flue-exhaust pipe. The haybox stove is another outdoor wood-burning stove. Haybox stoves use straw, wool, or foam as an insulator, reducing fuel use by up to 70%.[13]

Use in Europe

Italy is one of the biggest markets for pellet-burning stoves in Europe, having around 30% of all homes using wood for some heat. This means about 5 million homes have a wood fueled stove or cooker.

Types

- Franklin stove, originally invented by Benjamin Franklin, is a more efficient type of wood-burning fireplace. It was finicky and never caught on, but many stoves continue to be referred to as "Franklin" stoves.
- Carl Johan Cronstedt is reported to have increased efficiency of wood-burning stoves by a factor of eight in the mid-18th century.
- A Fireplace insert converts a wood-burning fireplace to a wood-burning stove. A fireplace insert is a self-contained unit that rests inside the existing fireplace and chimney. They produce less smoke and require less wood than a traditional fireplace. Fireplace inserts come in different sizes for large or small homes.[14]
- Down draft or cross draft gasification stoves, i.e. Dunsley Yorkshire, Welkom 600, Avalon Arbor™ wood stove, XEOOS.[15]
- Boiler Stoves provide hot water as well as space heating. A backboiler can be an optional insert added to the back of the firebox, or a wrap around water jacket that is an integral to the stoves structure. The choice determines how much of the stoves output goes to space heating as opposed to heating water.
- Rocket mass heater s are a type of fuel-efficient stove, named in the 70's, but dating back millennia in concept. A super-hot chimney above the fire draws the flames sideways and up, blending hot fuel and air into a quick, hot, clean-burning fire that takes little wood, leaves little residue, and has lots of uses.[16]

Rocket mass heater inside of a tipi at Paul Wheaton's permaculture homestead in Montana

Chimenea, burning wood for heat

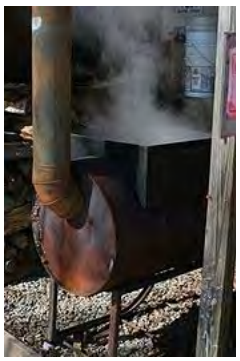
Daruma stove, a traditional Japanese wood-burning stove

Ceramic-tiled kachelofen wood-burning stove in an Alsatian house, Strasbourg, France. Wooden laundry-drying racks hang over the stove

New Mexico woman cooking on a stove typical of North American kitchens, in 1941

Wood-burning sauna stove, Finland

Custom-fitted fireplace insert with large glass doors, and a large heat exchanger for efficiency



Wood stove used as an outdoor "evaporator" for producing maple syrup, New York State

Small pot-bellied stove, Kabul, Afghanistan

Stove in the living room of a German farm

Stove in Massachusetts

See also

- Air-tight stove
- BioLite
- Bukhari (heater), traditional Indian wood stove
- Cook stove
- Kitchen stove
- List of stoves
- Masonry stove
- Portable stove
- Pellet stove
- Top-lit updraft gasifier
- Red Cross stove

Notes

a. This contradicts a claim made in the American History Channel Network's show *"101 Inventions That Changed the World"*, re-broadcast on 30 August 2016, which credited Ben Franklin as the inventor of the wood stove, ignoring the German origin. Franklin did patent an improved stove ca. 1744, including several variants such as a front of fireplace heating unit of cast iron, but his stove was based on existing stoves of German origin (i.e. Amongst the many 'Pennsylvania Dutch') found in the Province of Pennsylvania.

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