Proper Operation of Masonry Stoves and Furnaces

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Furnace operation.

Hundreds furnaces of different types are made from my drawings annually. I get all the information concerning furnace operation and problems revealed during operation. I have to find out the reasons of unsatisfactory operation of furnaces and mistakes made during their construction and operation. I have a unique possibility to systematize shortcomings in furnace operation, to reveal the reasons of drawbacks to be taken into account in further constructions and also to talk about their operating rules. Most likely nobody has such a possibility. The events described in the article are proved by large experience for many years in construction and operation of furnaces and fireplaces. In order that the furnace functions properly and has a long service life with maximum efficiency the furnace owner should learn the operation rules. <p>

Rules of drying process and trial heating.

A furnace has to be dried before operation. Firstly heat the furnace properly twice a day during 1,5-2 hours with a small amount of fuel (2 kg maximum and with humidity not more than 15 %) with the ash-pit and fire door open. It is not permitted to use splinter, wood chips and card board in big amounts. They will ensure high temperature for a short period that may cause crack formation. Heat the furnace in that way until formation of dew on external walls stops and there will be no moisture on the shut-off damper.

After that the furnace is to be dried, burning more fuel with the fire door closed. The chimney and ash-pit are left open during the whole period of drying, and the room is intensively ventilated. Depending on the furnace dimensions, the heating lasts 8-10 days in the summer time and 2-3 weeks in the fall and in winter.

High-speed heating causes cracking in bricklaying and can destroy the furnace prior to operation.

For trial heating fill the fire box full of fuel and burn it during 1,5-2,5 hours until the furnace walls warm up to the highest degree. Absence of smoking accounts for draught; touching the surface with a hand one can determine the heat level in different areas. Furnaces have to be checked and fixed before heating season starts.

Pay specifical attention to the bricklaying integrity starting from the first line up to the chimney top. Sometimes the frosty swelling force breaks the furnace and especially the chimney (the chimney on the attic has to be whitewashed to see cracking easily). Check the fire box condition and furnace equipment before the heating season starts and also during operation. Eliminate bricklaying cracking (fill up with a concrete bond or replace broken bricks) and fill cracking between bricklaying and furnace equipment (possible to use kaolin cotton dipped in clay mortar). It will improve the furnace work greatly, increase its efficiency and fire safety. The furnace heating in public places should be conducted by specially trained personnel, who have been instructed and who observe safety regulations, established by the fire-fighting regulations of RF and GOST 9817-82 “Domestic appliances, working on solid fuel”. The same requirements are to be met by every house owner.

The burning fuel process can be divided into three stages: burning start, active combustion and after-burning. Each stage needs different air volume for complete fuel combustion.

The biggest volume of air for fuel burning is required at the active combustion stage. It is known that firewood contain solid and volatile combustible matters. According to the data of K.Myakel “Furnaces and fireplaces” Stroyizdat 1987, for burning solid fuel constituent burning needs about

1,5 m³ for 1 kg of firewood. Volatile matter burning of 2,3 m³ per 1 kg of firewood needs only Totally 3,8 m³ of air is needed for 1kg of firewood.That is the optimum theoretical value. In practice air consumption is about 6-9 m³ per 1 kg of firewood. In this case the air excess is 1,6-2,4 times.

It should be noted that at the stage of burning start and after-burning the air consumption is less. If equal air volume of 6-9 m³ per 1 kg of firewood is supplied during the whole period of combustion reaction, the heat loss from incomplete burning will make 3-5 %, but at complete fuel burning at the stage of after-burning the heat loss is 20-35 %. (According to the data of Y.P.Sosnin and E.N.Bukharkin). Excess air will be three times more at the stage of burning start and 8-10 times at the stage of after-burning. However, if air is supplied in less than optimum amount, chemical incomplete fuel burning occurs. As a result, the energy contained in fuel, is not completely released (in other words, the efficiency of energy release from fuel is reduced), and also the unburnt volatile matters are deposited in the form of soot on the furnace walls. The soot has low heat conductivity and therefore soot deposits on the furnace walls reduce useful heat emission of furnaces. Besides, soot deposits reduce smoke flue sections and draught and create a fire risk, as the soot is combustible.

At the stage of burning start and intense burning the temperature in the furnace rises and decreases at the stage of after-burning.

From what has been said, it might be assumed that at the stage of intense burning the ash-pit door ought to be opened so that optimum air volume enters the furnace. The flame color is a good indication; the color should be light yellow. If the flame color is dark yellow combined with black smoke it means lack of air in the furnace, and burning reaction proceeds with a low efficiency and big deposits of soot on the furnace walls. It leads to furnace clogging, decreasing its heat emission and finally to fire risk. So at this stage it is strictly prohibited to stoke the furnace under smouldering burning condition with the ash-pit door closed. Bright white flame and strong humming indicates excess of air. In that case the ash-pit door has to be partially closed. At the stage of after-burning when carbons are left in the furnace, the ash-pit door can be fully closed. To control burning process of the furnace with the help of damper has no sense while at the stage of after-burning the damper should be half-opened to reduce chimney draught.

Keep in mind that 1 kg of carbon produces 8100 kilocalories of heat under complete burning turning into carbonic acid; but 1 kg of carbon will produce 2400 kilocalorie under incomplete burning (air deficiency) burning into carbon oxide, that is only29,6 % of energy.

Kindling and stoking procedure.

It is better to use paper, elm and resin kindling for ignition. It will allow to remove cold air removing from the chimney, to create draught and ensure ignition of wood at 300-350 C. When it is cold and the furnace has not been in use for a long time, it is better to start combustion with the shut-off damper open.

After ignition it is necessary to put dry wood into the furnace to achieve working temperature of 800-900 C.

The wood should be dried for 1-2 years, and have humidity of 15 % maximum. When raw wood is used the heat burning loss can reach 34-57 % according to the Finnish data sources. This also causes immediate furnace clogging and increases fire risk due to quick soot clogging. It is desirable to use logs of about equal thickness (5-10 cm) and humidity in order to burn them in the same period of time. Otherwise, unburnt single logs consume more heat than produce, so one cannot close the chimney until they burn completely. The same refers to the fireplaces.

Maximum heat emission is achieved by two stokings a day. The furnace shall be burnt twice a day (as a rule in the morning and in the evening) avoiding overloading the fuel box. When it's warm outside, burn the furnace only once. Open the furnace door seldom during stoking. While opening the door, large amount of air gets into the furnace, which does not take part in burning process and cools the furnace. I. S. Podgorodnikov has run a test: opening the door for 2-3 minutes caused reducing of temperature in the furnace by 420 C.

It is not allowed to fire the furnace while some arrangements are organized with many people involved. Do not store much wood in the room being heated. Store the wood sufficient for one burning only.

Do not overheat the furnace (90 C).

It is not allowed to fire the furnace at the stage of building construction, when designed heat circuit is absent. In that case, as a rule, the furnace gets overheated and destroyed.

It is not permitted to fire the furnace with highly flammable materials (petrol, acetone, etc).

For prolonged furnace operation and cleanness do not burn wastes, especially polymers, rotten and raw logs, varnished and painted wood, paper and cardboard. Substances, appearing during burning of these materials, deposit on the furnace (fireplace) walls and result in multiple fire risk increasing and polluting the environment. More than once we faced the situations when the furnace stopped operating in a month. Having opened the furnace it was found out that the bell of 13 cm width was completely clogged with soot deposited on the walls. In that case it is necessary to clean the bell walls from soot in turn and then burn through the bells with dry small aspen logs starting from the upper bell.

When loading new portions of fine dust fuel like sawdust and chips, rich in volatile combinations, do not close the whole fire bed surface area of burning (glowing coals, and it will be impossible to see open fire). This will result in formation of explosive mixture, which may cause an explosion and furnace damage.

Do not fire the furnace with coals and coke.

Open fireplaces are to be fired only with dry resin free (birch, aspen) logs not larger than 2/3 length of furnace box depth. It is prohibited to stoke fireplaces with coniferous types of wood (without safe protecting grid), as sparks may explode into the room.

The basic problems in furnace operation and trouble shooting procedure are given below (according to Podgorodnikov) with my additions.

1. While stoking the furnace with a stove the furnace does not get hot.

It happens when the furnace is stoked in a summer way. It's necessary to know properly which dampers are to be open in summer and which are in winter. <p>

2. The furnace emits smoke or burns badly.

It happens in a correctly built furnace when the holes for cleaning are not sealed up or raw logs are used for stoking. The same is possible in case of insufficient air supply to the fuel through the fire-grate (the ash is left in the ash bin), or if the chimney height or its section is insufficient. This happens in the Russian furnace named "teplushka" if the damper of the boiling chamber, through which the air inflow gets into the furnace is half-closed.

3. The furnace smokes while stoking it in the summer time.

In a hot summer day the chimney is filled with cold heavy air. The air column filling the chimney is much heavier than the outside air column of the same height, and so the air column in the chimney goes down, pushes out the air and smoke during ignition at the same time. Warm up the chimney first in order the gases in the chimney get warm and become lighter than the air

outside. For that stoke the furnace like you do it in summer, or put a burning bunch of paper or splinters into the chimney through the damper.

One can heat the chimney with a bunch of rolled newspapers through the fireplace, arranging the fire higher than the fireplace ceiling.

4. Smoking happens sometimes in correctly built furnaces and especially in the fireplaces inside comfortable stone houses with airproof walls, floor, ceiling, doors and windows.

Soon after the stoking start the furnace or fireplace begin to smoke. This happens due to consumption of room air for burning, which results in formation of underpressure in the room, the same as in the fire box. As the room walls are air-tight, the atmospheric pressure is not transferred into the room. Open the air vent to stop smoking. If there is a fireplace in the room, arrange inflow of fresh air; make sure that it comes to the burning area.

5. Sometimes one comes across problems with eyes (like reddening and irritation) after stoking the fireplace.

Usually exhaust air channels are arranged in the same pipe with fireplace chimney. If during fireplace burning no fresh air comes through a special air supply channel than low pressure is created in the room, and exhaust channel starts suctioning flue gases into the room.

6. It's prohibited to install an air exhauster with forced ventilation which is uncompensated by inflow with forced ventilation in a room provided with stove.

Otherwise, due to the forced ventilation, low pressure is created in the room and the fireplace or the furnace starts smoking.

Very often stove men do not consider the air inflow coming into the fireplace burning area, and designers while making estimation of ventilation balance do not take into account the air coming through the fireplace, designing insufficient inflow ventilation.

7. The furnace provided with a built-in water tank, coil, and boiler of hot water supply or heating can emit smoke if the system has water or steam leakage, getting into the furnace.

8. It may occur during the process of furnace operation that the whole furnace becomes covered with cracks.

It is usually the result of poor furnace foundation (for instance, on the fill-up soil) or when the furnace foundation is extended without its connection with the main monolith.

9. The furnace refractory lining is destroyed.

It happens when the acid-proof brick is used instead of fire-brick by mistake. The brick does not really differ from the fire-brick. Before using the fire-brick get acquainted with its certificate.

10. It may happen that suddenly the furnace or fireplace starts smoking.

The reason of smoking is that the chimney is made with deviations from the norms:

- The required chimney height above the roof is not met;
- The chimney is in wind-induced back draught area due to neighboring higher building.

When wind direction above the chimney changes it creates high or low pressure.

Under these circumstances it is necessary to raise the chimney or install wind-proof devices in the form of wind vanes or deflectors. It should be noted that international standards demonstrate more strict requirements regarding the chimney height above the roof. So it is better to raise the chimney 1-2 lines higher than it is normally required.

11. The chimney gets wet even if it is equipped with a chimney cope, head and deflector, protecting the chimney from atmospheric precipitation.

Any fuel has some amount of water. Burning the fuel water turns into steam and together with the smoke fumes comes into the chimney. If gases passing through the chimney have the temperature below 100° C, the steam turns into water again and precipitates on the chimney walls. The accumulated water flows down the chimney. After the stoking is finished the water freezes, and destroys the chimney. To avoid damage the smoke fumes steam must turn into water only after leaving the chimney, in other words, the temperature of gases themselves in the chimney should be above 100° C. But releasing of hot gases into the chimney is also prohibited, as the warmth should be used for heating the chimney. Tests have confirmed, that the chimney does not get moisturized and the furnace operates efficiently under the temperature of smoke fumes near the damper of about 250° C (dry pins under this temperature become rye-bread crust colored).

Low temperature of gases in the chimney may be due to the following reasons:

- Constructive reasons: gas flow faces excessive resistance slowing down its movement, long baffle with turns at right angles; the passes are made narrow, the turns are added, a cold body is in the fire box (heating or hot water supply boiler), etc. At the same time gases are much cooled in the furnace before leaving the chimney;
- Fuel does not completely cover the fire-grate, so the air does not strain through the fuel layer but passes in a big volume into the furnace past the fuel and cools smoke fumes to a large extent;
- The same happens when the spurious air penetrates through bricklaying cracks, through the cracks in the furnace and cleanout doors, stove and especially through the half-closed shut-off damper of the Russian “teplushka”;
- Insufficient air volume with the ash-pit door closed under the active combustion condition;
- Raw logs
- The furnace is clogged or the ash-pit is completely clogged with soot ;
- During installation of metal chimney its walls were not properly insulated.

12. Insufficient heating of stones (stones are covered with soot), in correctly built Russian steam sauna of periodic action.

This may be due to the following reasons:

- Incorrect furnace stoking under smouldering burning condition with lack of air;
- Furnace heating with a small thickness of fuel layer at the complete combustion;
- The untight door for pouring water on stones (candle flame is not supposed to move to the door crevice), the same is possible due to frequent opening the door during furnace heating.

13. Poor water heating in the Russian steam sauna and boilers.

This may be due to the following reasons:

- A ball cock of foreign manufacture for water heating regulation is fitted on the return pipe. It has constricted clearing hole. Replace the ball cock and install the valve of domestic manufacture, having a proper clearing hole. The same will happen if the water heating regulation valve is closed, and water circulation takes place only inside the straight pipe;

- The coil (register, boiler) is wrongly manufactured or installed. The pitch of pipes for water drain from the system should be provided in the direction from the straight pipe to the lower part of return pipe (where the drain cock is installed). Otherwise the air-lock will be formed at the top of coil (register, boiler), which prevents water circulation. During water heating pressure in the air-lock becomes higher, and hammering takes place in the system of heating or hot water supply, that may result in the system break-up;
- Tank manifolds are made with counter grades and as a result air-locks are formed inside the pipe preventing circulation of water;
- The air-lock formation and as a result poor water circulation becomes possible if inlet and outlet branch pipes of a tank are made on the same height. Filling the tank water comes into the both pipes simultaneously. After manifolds correction and changing the height of the branch pipes water heating becomes better;
- The space between inlets of straight and return pipes into the tank is made very small, and so water circulation slows down significantly (the circulation is more intensive when the temperature difference in the pipes is large). Inlet pipes shall be installed at different tank sides. In order to improve water circulation one can use a partition with holes to separate branch pipe of the return pipe.
- The tank has been insufficiently lifted above the coil upper pipe; it should be installed 150 mm higher.

Additional rules for stoking multi-storied furnaces.

One can stoke all the furnaces located on different stories at the same time, or any one or two furnaces separately. While stoking separate furnaces on different stories the shut-off dampers of non-used furnaces should be closed.

A**pplication of shut-off dampers of OIK and OVIK furnaces.**

Upper shut-off damper of the furnace (opened while stoking)

Low shut off damper of summer usage, bottom (it is used during stoking start, then it should be closed or left open in OVIK furnace type of summer usage.

Interesting facts are published in the third edition 1(3) 2000 of the “Fireplaces and heating” magazine concerning the heat energy generation price per unit using different energy types to unite price. The current data are given in the article on page 62.

Comparative price list per unit using different energy sources of heat energy generation.

Wood – 1 unit price

Coal – 2,68

Purchased heat energy – 13,83

Diesel oil – 14,13

Electric power – 24,47

As can be seen, the cheapest (and ecologically clean) heat energy is received by using wood.

04/2003

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