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FEATURES OF DIGESTIVE BOILERS IN THE RESTAURANT BUSINESS AND FOOD INDUSTRY

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The article describes the features of thermal cooking technological equipment. The paper examines the peculiarities of the interaction of thermal cooking equipment with food raw materials and food products and gives an overview of the application for various technological processes in the food industry and restaurant establishments. Despite the large number of scientific works devoted to the topic of technological equipment, in particular cooking equipment, in Ukraine this is an insufficiently covered topic that needs research, given the current conditions in the national economy. The structure and principles of operation of digestive boilers with direct and indirect heating in catering establishments are considered. The use of boilers makes it possible to speed up the cooking process; specific energy consumption and heat loss are lower compared to stoves. During cooking in modern pans, heat losses exceed 50% of the used power of the burner. The working chamber of the boiler is surrounded by a steam-water shell, where superheated steam under pressure effectively transfers the heat of the contents of the cooking vessel through the entire surface of the wall. The tight lid on the cooking container prevents heat loss from above. Cooking boilers are installed in canteens, restaurants, and other food outlets with a large

number of visitors. Electric boilers with indirect heating are equipped with a steam generator to produce steam from distilled water. The heating elements are TENs, which are fixed on the flange with a common block. The block is attached to the steam generator body using screws. In restaurants, mostly electric and gas boilers are used, less often – steam boilers. Performance indicators of boilers depend on the mode of operation and correct operation. All performance indicators affect the efficiency of the boiler or depend on it. The operational characteristics of the boilers are improved if the cooking vessel is heated by two groups of heaters located near the bottom and walls, and if the thermostats are correctly set, which prevent violent boiling of the liquid, including when the working chamber is not completely filled. The coefficient of useful action increases with an increase in the load factor of the cooking vessel during heating of the contents of the boiler to boiling, as the specific heat exchange surface decreases.

Key words: *technological equipment, cooking equipment, TEN, digestion boiler, turbine valve, steam valve, vacuum valve, restaurant establishments.*

Криворучко М. Ю., Антоненко А. В., Расулов Р. А., Ратушенко А. Т., Горкун А. О., Тонких О. Г. Особливості стравоварильних котлів у ресторанному бізнесі та харчовій промисловості

У статті описано особливості теплового варильного технологічного устаткування. У роботі розглянуто особливості взаємодії теплового варильного устаткування з продовольчою сировиною та харчовими продуктами та дано огляд застосування для різних технологічних процесів у харчовій промисловості та закладах ресторанного господарства. Незважаючи на велику кількість наукових праць, присвячених темі технологічного обладнання, зокрема варильного устаткування, в Україні це недостатньо висвітлена тема, яка потребує дослідження, враховуючи сучасні умови в національній економіці. Розглянуто будову та принципи дії стравоварильних котлів з прямим і непрямим нагрівом у закладах харчування. Використання котлів дає змогу прискорити процес варіння; питомі витрати енергії та втрати теплоти менші, порівняно з плитами. Під час варіння у сучасних каструлях теплові втрати перевищують 50 % від використаної потужності конфорки. Робоча камера котла оточена пароводяною оболонкою, де перегріта пара під тиском ефективно передає теплоту вмісту варильної ємності крізь усю поверхню стінки. Щільна кришка на варильній ємності запобігає втратам теплоти згори. Стравоварильні котли встановлюються в їдальнях, ресторанах, інших пунктах харчування з великою кількістю відвідувачів. Електричні котли з непрямим нагріванням оснащені парогенератором для виробництва пари з дистильованої води. Нагрівальними елементами є ТЕНи, які закріплюють на фланці спільним блоком. Блок приєднують до корпусу парогенератора за допомогою гвинтів. В закладах ресторанного господарства переважно використовують електричні і газові котли, рідше – парові. Показники роботи котлів залежать від режиму роботи та правильної експлуатації. Усі показники роботи впливають на коефіцієнт корисної дії котла або залежать від нього. Експлуатаційні характеристики котлів покращуються, якщо варильна ємність нагрівається двома групами нагрівачів, розміщеними біля днища та стінок, та за умови правильного налаштування терморегуляторів, які запобігають бурхливому кипінню рідини, в тому числі під час неповного заповнення робочої камери. Коефіцієнт корисної дії зростає зі збільшенням коефіцієнта завантаження варильної ємності під час нагрівання вмісту котла до кипіння, оскільки знижується питома поверхня теплообміну.

Ключові слова: *технологічне устаткування, варильне устаткування, ТЕН, стравоварильний котел, клапан-турбінка, паровий клапан, вакуумний клапан, заклади ресторанного господарства.*

Introduction. Cooking is a process of hydrothermal processing of products in order to bring them to culinary readiness. During cooking, proteins are denatured and coagulated, the collagen of the connective tissue of meat and fish raw materials is transformed into gluten, the majority of vegetative microorganisms die, and enzymes are inactivated.

The medium for cooking is water, broth, milk, sauce, juice, syrup, moisture and saturated steam. Regardless of the intensity of the heat flow during cooking, overheating of the product surface does not occur, semi-finished products are gradually heated evenly throughout the entire volume to the state of culinary readiness.

The cooking process can be accelerated by increasing the temperature and pressure in the cooking vessel. The disadvantage is the increased thermal destruction of the

product components, which worsens the quality of culinary products. The rate of nutrient transition into cooking water depends on the difference in their concentrations in the environment and near the surface of the product. Thus, cooking is not only a heat exchange process, but also a complex mass exchange process.

Cooking can be done in the main way and in steam. Cooking in a large amount of liquid is characterized by a significant concentration difference between the product and the medium. If the products are immersed in boiling water, the output of the culinary product increases, since a smaller amount of extractive substances passes into the water. For the preparation of broths, on the contrary, they seek to transfer more nutrients into the environment, so the raw materials are put in cold water, and then brought to a boil. During steam cooking, the surface layer of the product is dehydrated, which reduces the loss of mass of finished products.

Formulation of the problem. Let's consider the dynamics of temperatures during the cooking of products in a digestive cauldron or in kitchen utensils. During heating of the cooking medium, its temperature rises to 100 °C. Next, the product is fed into the cooking container and the temperature of the cooking medium drops rapidly. The heating device must have sufficient power to quickly restore the temperature, otherwise the productivity of the equipment decreases, and the quality of culinary products deteriorates.

After restoring the cooking temperature, the intensity of heat supply to the cooking medium is reduced. In specialized cooking devices, this happens by automatically adjusting the power of the heaters. During cooking in a plate dish, the power of the heating elements is changed manually. After the heaters are completely turned off, the product is brought to readiness using the accumulated heat. In this way, for example, porridge is prepared in the conditions of restaurants.

Cooking boilers are designed for cooking food products in a large amount of liquid; sometimes used for steaming. The design of the boilers should ensure that the product is heated to no higher than 100 °C and ensure the regulation of the cooking mode within the limits of the boiling temperature. The technological environment of food boiling boilers is water or broth with a temperature of 100 °C.

The aim of the study. The purpose of the work is a scientific study of the principles of operation of thermal cooking equipment in restaurants and the food industry.

The object of the research is thermal cooking equipment and the principles of its operation.

The subject of the study is digester boilers with direct and indirect heating.

Analysis of recent research and publications. Scientific substantiation and development of competitive technological equipment is an urgent task, the solution of which will allow expanding the range of food products and obtaining products with specified properties.

The research of the following domestic and foreign scientists made a significant contribution to the solution of fundamental issues of technological equipment for the creation of food products: O.O. Grinchenko, A.B. Horalchuk, A.M. Dorokhovych, I.Yu. Zhigalenko, A.V. Ziolkovska, M.B. Kolesnykova, H.M. Lysyuk, L.P. Malyuk, L.M. Mostovoy, N.Ya. Orlova, M.I. Peresichny, P.P. Pivovarova, N.V. Prytulska, G.B. Rudavska, M.R. Ennis, J.C.F. Murray, G.O. Phillips, W.C. Weling, P.A. Williams et al. [1-10].

Presentation of the main research material. Cooking pots are used to prepare soups (first dishes), main hot dishes (second dishes), side dishes; cooking hot drinks, sweet dishes; boiling products for further use in the production of cold dishes and

snacks; boiling large amounts of water or milk; preparation of some universal semi-finished products (broths, sauces, etc.). With the help of special perforated inserts, it is possible to cook with steam. The technological medium of boilers is water or broth with a temperature of 100 °C.

The use of boilers makes it possible to speed up the cooking process; specific energy consumption and heat loss are lower compared to stoves. Yes, even during cooking in modern pans, heat losses exceed 50% of the used power of the burner. The working chamber of the boiler is surrounded by a steam-water shell, where superheated steam under pressure effectively transfers the heat of the contents of the cooking vessel through the entire surface of the wall. The tight lid on the cooking container prevents heat loss from above. Cooking boilers are installed in canteens, restaurants, and other food outlets with a large number of visitors.

The most widespread universal boilers, in which to cook any food products, prepare broths, soups, heat milk, prepare dairy culinary products, boil meat, fish, vegetables, prepare compotes, etc. Specialized devices designed for the preparation of certain types of food products (pasta products, sausages, etc.) have a simpler design – these devices are also classified as digestive boilers.

In restaurants, mostly electric and gas boilers are used, less often – steam boilers. Solid-fuel and liquid-fuel boilers are in demand in army and field conditions, as well as high-altitude hotels. According to the structural feature, such boilers are also modular and non-modular (island). The most common are boilers with a cylindrical cooking vessel or with a cooking vessel in the form of a parallelepiped. Boiling containers are stationary and tiltable (with the help of a worm mechanism, the cooking container rotates around a horizontal axis). Boilers with a cooking capacity of up to 250 dm^3 are in demand in the restaurant industry.

A design feature of boilers with direct heating is direct contact of the heating element or combustion products with the wall of the working chamber or the working environment. It is advisable to use such boilers at those enterprises where the cooking processes are auxiliary and short-term.

Cooking boilers with direct heating are electric, gas and solid fuel. They are simple in design and operation, but have significant disadvantages:

- uneven temperature distribution on the working surface;
- there must be local overheating of the surface and a high probability of the product burning;
- low efficiency;
- the thermal regime is difficult to regulate;
- due to unevenness of the temperature field on the surface of the working chamber, it is difficult to automate the brewing process;
- during work, constant monitoring of personnel and periodic mixing of the product in the working chamber is required.

Electric boilers with direct heating are divided into four groups according to the type of heater. The first group includes boilers with a closed-type electric heater installed in the bottom of the cooking vessel. With this way of placing heating elements, there is a high probability of products burning: power regulation in electric boilers with direct heating is carried out in a discrete way, that is, by turning off or turning on a certain number of heaters, which creates zones of local overheating of the working surface.

Equalization of the temperature field is possible by increasing the contact area of the heating elements with the working surface. This makes it possible to reduce the specific power of heating elements and reduce the probability of product burning. The named

structural solution is used in boilers of the second group, in which flexible tape heaters are used.

In boilers with band heaters, it is difficult to heat the bottom of the cooking vessel. When the working chamber is incompletely filled, a large part of it heats up without contact with the product. It is possible to effectively distribute the heat in the cooking vessel in boilers of the third group, in which the technology of sprayed semiconductor resistive layer is applied.

The electrical resistance of the resistive layer increases rapidly in a narrow temperature range and stabilizes at a certain level. The use of a resistive layer facilitates the automation of the apparatus, as the system becomes self-regulating.

Devices with a semiconductor resistive layer exist only as experimental samples. Mass distribution is hindered by the technical complications of uniform sputtering of the resistive layer and application of electrical insulation. The fourth group includes specialized cooking devices, where the heating element is immersed in the cooking medium inside the cooking container. Boilers with an immersed heater are mass-produced in the form of highly specialized small-sized devices for cooking sausages, dumplings, and pasta. To avoid contact of the product with the heating element and to reduce the possibility of product burning, the raw materials are placed in special perforated containers or mesh baskets. During the operation of such boilers, the cooking liquid should be changed in time to avoid thermal destruction of extractive water-soluble substances.

Fire boilers with direct heating work on gas, solid and liquid fuel. In these boilers, it is difficult to achieve uniform heating of the wall of the cooking vessel, so there is a high probability of products burning. During fuel burning, combustion products heat the outer wall of the cooking vessel. Combustion products have a maximum temperature (about 1000...2000 °C), which decreases during movement in gas ducts and at the exit is at least 300 °C. This leads to overheating of the working chamber.

There are ways to soften heat exchange:

− dilution of fuel combustion products with air, but this leads to a decrease in efficiency);

− use of a cooking vessel made of materials with a high coefficient of thermal conductivity and an increase in the wall thickness to 10...15 mm;

− use of a multi-layer structure with an aluminum layer. Operation of fire boilers with direct heating is possible only with constant monitoring of the cooking process by personnel.

In steam boilers with direct heating, the energy carrier is moist saturated steam that moves inside the steam heat exchanger located directly in the cooking vessel. The cooking vessel is not in direct contact with the heater. The wall of the steam heat exchanger is in direct contact with the cooking medium. Similarly to electric boilers, products are placed in mesh baskets. Thus, steam digester boilers with direct heating of the medium are used in restaurants as highly specialized heating devices.

Most of the digester boilers offered on the market today have indirect heating of the working chamber with the help of a steam-water jacket. The intermediate coolant between the heat generator and the wall of the cooking vessel is saturated steam with a temperature of up to 110 ºC. Under conditions of constant pressure in the steam envelope on the wall of the cooking vessel, an isothermal field is formed, since the isobaric process is simultaneously isothermal for moist saturated steam. The use of an intermediate coolant in cooking devices with a shell creates a uniform temperature field on the wall of the cooking container.

Electric boilers with indirect heating are equipped with a steam generator to produce steam from distilled water. The heating elements are TENs, which are fixed on the flange with a common block. The block is attached to the steam generator body using screws.

The lampshades must be completely submerged in water. In the air, they overheat and quickly fail. The operation of heating elements in air is called "dry running". To avoid this phenomenon, it is impossible to allow the water level in the steam generator to decrease. The water level in the steam generator is regulated using a level tap.

An additional wall is placed around the cooking vessel of the boiler at a distance of 10...40 mm. It is hermetically connected to the cooking vessel by welding. The closed space formed is a vapor envelope. A steam generator is located below the shell. A drain tap is mounted from the bottom of the cooking vessel. The unit "cooking container-steam shell" is covered with thermal insulation and a decorative casing. In small-capacity boilers, this unit is placed on a fork-shaped bed, which makes it possible to rotate the cooking vessel around a horizontal axis using a worm gear or drive. This facilitates and accelerates the unloading of the finished product.

The steam generator with heating elements is filled with water to the required level through the filling funnel. The water level is regulated by the level tap. Measurement of pressure in the steam envelope and control of the technological process is carried out using an electric contact manometer or pressure switch. A double safety valve is provided to protect the shell from bursting under high pressure or crumpling during pressure reduction.

When the heaters are turned on, the water in the steam generator heats up and boils. Moist saturated steam moves up in the steam jacket, gives the latent heat of steam formation to the wall of the cooking vessel and condenses. The temperature of the cooking vessel increases and as it approaches the boiling point, the vapor pressure in the shell increases.

During the boiling of water in the working chamber, the pressure in the shell increases to such a level that the needle of the electrocontact manometer reaches the upper fixed contact needle. This leads to a short circuit in the electrical contact relay and the boiler power is automatically reduced. Relays are also provided in the steam generator. They turn off the heating elements when the water level in the steam generator drops below the permissible level.

Consider steam boilers with indirect heating. There are two design options for these digester boilers. Both designs involve the use of centralized steam supply. In the first version, the wall of the working chamber is heated by primary steam coming from the boiler room. The formed condensate from the shirt flows through the non-return valve to a special pipeline. A purge valve is provided to remove air from the shirt.

In the second version of the design, secondary steam is used, which is generated in a built-in steam generator using a steam tube heat exchanger. The primary steam moves in the heat exchanger, heats the water in the steam generator. Secondary steam is formed, which enters the steam-water jacket of the boiler.

Condensate from the jacket enters the steam generator, and from the heat exchanger – into a separate pipeline. Air is removed from the shirt and the heat exchanger in separate ways: a blow-off valve is provided for the heat exchanger, and air is removed from the shirt through a filling funnel. The main purpose of the watering can is to fill the steam generator with water.

The design using primary steam is more reliable than with a heat exchanger. A scheme with a steam-immersed heat exchanger that generates secondary steam is advisable if the primary steam is supplied with a pressure of at least 500 kPa, otherwise the surface

of the steam heat exchanger will not be sufficient. Technical means for the operation of safety systems and regulation of equipment are called fittings. Safety fittings include: double safety valve, turbine valve, safety explosion membrane. regulating fittings – electric contact manometer, pressure switch, devices for draining condensate. The safety valve includes a pressure gauge and a level control valve. For shut-off valves – water drain valves, steam valves, non-return valves, purge and air valves.

The turbine valve is installed on the hermetically sealed covers of the working chambers. The device prevents the pressure in the cooking vessel from increasing by more than 2.5 kPa (0.025 atm) above atmospheric. As a result of an increase in the pressure in the working chamber above the atmospheric pressure, the steam-air mixture from the cooking vessel comes out. The steam enters the spiral grooves of the turbine, where the force of the steam is divided into two components: horizontal and vertical. The horizontal component determines the rotational movement of the turbine. The vertical component of the force lifts the valve. Raising the valve reduces the working length of the turbine groove and the steam output increases. In an extreme situation, the turbine lifts and rotates the cargo sleeve. The sleeve pushes the upper valve up; due to this, the size of the opening for the release of steam into the atmosphere increases.

Even rotation of the ring on the rod indicates the proper operation of the valve. Too high a speed of rotation of the ring means a critical increase in pressure. It is necessary to reduce the intensity of heating.

A strong release of steam behind a stationary ring indicates sticking of the turbine to the valve body. This is an emergency that means the valve is malfunctioning. It is necessary to completely stop the cooking process. In some designs, it is possible to manually lift the turbine with a special lever if the turbine is stuck to the housing. This technique is also used to equalize the pressure in the working chamber with atmospheric pressure before opening the lid.

The electric contact manometer is designed to regulate the pressure level in the boiler shell and the cooking mode. A movable pointer (manometric) arrow indicates the amount of pressure in the shirt, two fixed arrows are set on the minimum and maximum pressure marks. During the operation of the boiler, the manometric needle moves and when in contact with the needles or the electrical circuit is closed. This causes the heaters to turn on or off (or supply gas to the burner) To prevent deformation of the outer wall of the boiler shell as a result of pressure changes during steam heating or cooling, the shell is equipped with a double safety valve, which includes steam and vacuum valves.

A steam valve prevents the shell from bursting as a result of increased pressure. When the critical pressure is reached, the steam lifts the spool with the cargo sleeve and escapes to the atmosphere. The vacuum valve is designed to equalize the pressure inside the shell with atmospheric pressure after the boiler is turned off, which prevents the shell from crumpling. When the pressure decreases, a vacuum is created in the shell, the spool of the vacuum valve rises and air enters the shell from the outside. The double safety valve is designed for the safe operation of the "boiler-steam jacket" unit under excess pressure up to 50 kPa. Some valves of this type are additionally equipped with a lever for manual lifting of the steam valve with a cargo sleeve. This makes it possible to remove air from the steam jacket, that is, to carry out blowing.

Conclusions. Performance indicators of boilers depend on the mode of operation and correct operation. All performance indicators affect the efficiency of the boiler or depend on it. The operational characteristics of the boilers are improved if the cooking vessel is heated by two groups of heaters located near the bottom and walls,

and if the thermostats are correctly set, which prevent violent boiling of the liquid, including when the working chamber is not completely filled. The coefficient of effectiveness increases with the increase in the load factor of the cooking vessel during heating of the boiler contents to boiling, as the specific heat exchange surface (ratio between the heating surface and the useful volume of the boiler working chamber) decreases. And vice versa, the efficiency of the boiler decreases under operating conditions with an incompletely filled cooking tank: reducing the boiler content by 1 dm^3 reduces the efficiency by 0.5%. In modern models of boilers, a mode of softened heat treatment of raw materials at temperatures of 75...80 ºC is provided. As a result, 50% more ascorbic acid and other biologically active substances are stored in vegetables. Generalized information about modern innovative constructive solutions of digester boilers indicate a significant expansion of the scope of application of these thermal devices.

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