

UHF Device Introduction for Animal Raw Material Processing

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Received: 20th April 2020, Accepted: 05th May 2020, Published: 30th June 2020

Abstract

The calculation of technical and economic indicators for a microwave implementation with a squirrel cage resonator at farms was carried out according to the standard method, taking into account the cost item:

1. The book value of the designed and manufactured microwave device (design model);
2. Operating costs for heat treatment of lumpy meat during the massaging in brine according to the design model;
3. The book value of the meat massager Gambit-120 (basic version);
4. Operating costs for lumpy meat massaging in a brine in vacuum and heat treatment in a separate heat chamber (basic version)

Keywords

Electromagnetic Field of Ultrahigh Frequency, Resonator Chamber, Meat Raw Materials, Economic Efficiency.

Introduction

The economic effect of using the installation with a microwave energy source for heat treatment in the process of massaging small-baked meat raw materials in comparison with the combined use of the Gambit-120 meat smoker and the KoptiSam-120NPP Smokehouse is achieved by reducing operating costs when the volume of output is 16.8 tons per year.

Background

Below we analyzed the economic efficiency of a microwave use at agricultural enterprises of medium and low power due to lower operating costs for the heat treatment of lumpy meat during its massaging in brine.

Table 1: The Estimation of Microwave Energy Device for Raw Meat Heat Treatment in the Process of its Massaging in Brine

Name	Amount	Cost
Aluminum pipe (diameter 1 cm)	60 m	16000
Aluminum sheet 1.5 x1.5 m	1 pc.	5 000
100 L aluminum tank	1 pc.	5 000
Metal profiles (40x20)	12 m	3 000
Microwave generator (1200 W)	1 pc.	5 000
Electric drive with gear (0.5 kW)	1 pc.	10000
Start-up equipment		5000
Manufacturing costs		22 000
Commissioning works		6 000
TOTAL		77 000

The book value of the designed microwave unit with an unconventional squirrel cage resonator (Fig. 1) for lumpy meat heat treatment during its massaging in brine makes 77,000 rubles.

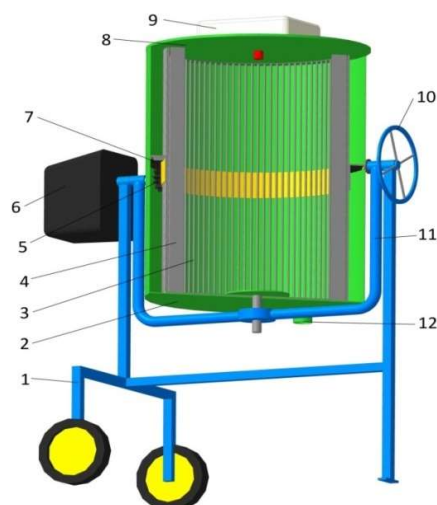


Figure 1: Microwave Device with Diffractive Cylindrical Resonator (Design Model):

1 - Mounting frame on wheels; 2 - Cylindrical shielding case; 3 - Cylindrical resonator; 4 - Inner ribs; 5 - Pinion gear; 6 - Gear motor; 7 - Ring gear; 8 - Shielding housing cover; 9 - Generator block with magnetron and emitter; 10 - Device locking mechanism; 11 - Rotary frame for support and device angle change; 12 - Drain pipe

Operating costs for lumpy meat heat treatment in a microwave during the process of massaging in brine for 1 month according to the design model

The productivity of the prototype microwave device is 8 kg/h (for raw materials - bird offal, small-piece pork) ($8 \cdot 7 \cdot 25 = 1400$ kg/month, 16.8 t/year).

The labor costs of the technologist servicing the device:

$11163 \cdot 1.09 \cdot 1.2 \cdot 1.97 = 28764.4$ rubles/month,

where 11163 rub. - minimum wage of the 1st category operator; 1.09 - tariff coefficient of the 3rd category employee; 1.2 - industry coefficient for the working condition; 1.97 - the total ratio of all surcharges and charges to the tariff rate.

Electricity Costs

Electric power of a squirrel cage (diffraction cylindrical resonator) makes 0.5 kW; microwave generator power makes 1.2 kW; fan power for magnetron cooling makes 0.15 kW. The total capacity of the device makes 1.85 kW.[1] Then, the energy costs of lumpy meat heat treatment and massaging (soft consistency in brine) at a plant capacity of 8 kg/h make $E = 1.85/8 = 0.231$ kW · h/kg.

Taking into account the electricity tariff in the Nizhny Novgorod region for armers in 2018 equal to (5.98-6.88) rubles/kW·h the costs are $6.0 \text{ rubles} / \text{kW} \cdot \text{h} \cdot 0.231 \text{ kW} \cdot \text{h} / \text{kg} \cdot 1400 \text{ kg} / \text{month} = 1940.4$ rubles / month.

Depreciation deductions: $77000 \cdot 0.2 / 12 = 1283.3$ rubles / month.

Maintenance: $77000 \cdot 0.24 / 12 = 1540$ rubles / month.

Other expenses:

$(28764.4 + 1940.4 + 1283.3 + 1540) \cdot 0.05 = 1676.4$ rub./month.

General production expenses:

$(28764.4 + 1940.4 + 1283.3 + 1540 + 1676.4) \cdot 0.15 = 5280.66$ rub./month.

Total operating costs:

$28764.4 + 1940.4 + 1283.3 + 1540 + 1676.4 + 5280.66 = 40485.2$ rub./month.

The cost of operating costs for heat treatment in the process of lumpy meat massaging in a device with a microwave energy source:

$40485.2 / 1400 = 28.92$ rub./kg.

Cost of heat-treated product according to the design model: [2]

If the price of raw materials as of November 1, 2018 makes 200 rubles/kg, then the cost of boiled meat product makes $200 + 28.92 = 229$ rubles / kg.

Result & Discussion

Operating costs for the process of meat massaging in the brine according to the basic model (without heat treatment). The book value of the vacuum meat massager Gambit-120 makes 100 thousand rubles.[3]

The first basic version is represented by vacuum Gambit-120 meat massager (Fig. 2), the manufacturer - RBG "Gambit" Concrete Mixers (Russia, Stavropol Territory, Stavropol, 1st South-West passage, 8-8800100-35-63).

The cost of the unit makes 100 thousand rubles excluding computer, and measuring equipment. Electric drive power makes 0.6 kW, drum volume - 120 l.



Figure 2: Meat Massager Gambit-120

The "Gambit-120" stainless steel industrial vacuum meat massager is designed to massage meat in a discharged container with brine to improve consumer properties and increase the yield of the finished product (smoked products).[4] The technological process takes place in a closed drum. Due to the special configuration of the three blades, the lumping of meat occurs inside the rotating drum. Product quality depends on the drum rotation speed, the duration of massage, the concentration of brine and vacuum. The massager is equipped with a tipping unit.[5] Calculation of the meat massager Gambit-120 performance. The volume of the drum makes 120 l. You can load up to 25% with raw materials, i.e. within 25 kg of raw materials and 5 l of brine. The duration of pork, lumpy meat massaging makes 2.5-3 hours. Then, productivity will be up to 10 kg/h on average. Considering vacuum duration (0.5 h) before turning on the electric drum and depressurization after the end of massaging (0.5 h), the cycle time will be 3.5 hours.[6]

Therefore, the productivity of the process makes $25/3.5 = 7$ kg/h.

The number of cycles per day is 4, i.e. the unit can massage 100 kg per day (for 24 hours), and 2500 kg per month. Or in a 7-hour work day: $7 \text{ kg/h} \cdot 7 \text{ h} \cdot 25 \text{ work. days} = 1225 \text{ kg / month.} = 14.7 \text{ t/year.}$

The cost of device operator makes 28764.4 rubles/month.[7]

The cost of electricity in the basic unit is provided for the electric drum (without heat treatment)

Specific energy consumption $0.6 \text{ kW} / 7 \text{ kg} / \text{h} = 0.086 \text{ kW} \cdot \text{h} / \text{kg}$

$0.086 \text{ kW} \cdot \text{h} / \text{kg} \cdot 1225 \text{ kg} / \text{month} \cdot 6.0 \text{ rubles} / \text{kW} \cdot \text{h} = 632 \text{ rubles} / \text{month.}$

The tariff for small enterprises, calculated according to the first price category, with a maximum power of less than 670 kW, connected to electric networks by the LV voltage level (0.4 kV) 2018 makes 6 rubles / kWh for September.

Drum Vacuum Costs. The vacuum pump power makes $0.55 \text{ kW} / \text{m}^3 \cdot \text{h}$

$0.55 \text{ kW} \cdot \text{h} / \text{m}^3 \cdot \text{h} \cdot 6 \text{ rubles} / \text{kW} \cdot \text{h} = 3.3 \text{ rubles} / \text{m}^3$. If during the working day we load the meat massager twice, then the cost will be $3.3 \cdot 2 \cdot 25 = 165 \text{ rubles} / \text{month.}$

Total average electricity costs

$632 + 165 = 800 \text{ rub/month.}$

Depreciation deductions: $100,000 \cdot 0.2 \cdot 1/12 = 1666.7 \text{ rubles} / \text{month.}$

Maintenance: $100,000 \cdot 0.24 \cdot 1/12 = 2,000 \text{ rubles} / \text{month.}$

Other expenses: $(28764.4 + 800 + 1666.7 + 2000) \cdot 0.05 = 1661.6 \text{ rubles} / \text{month.}$

General production expenses:

$(28764.4 + 800 + 1666.7 + 2000 + 1661.6) \cdot 0.15 = 5234 \text{ rubles} / \text{month.}$

Total operating costs:

$28764.4 + 800 + 1666.7 + 2000 + 1661.6 + 5234 = 40126.6 \text{ rubles} / \text{month.}$

The operating costs for lumpy meat massaging in brine under vacuum: $40,126.6 \text{ rubles} / \text{month} / 1225 \text{ kg} / \text{month} = 32.75 \text{ rubles} / \text{kg.}$

The cost of the semi-finished product after raw material salting and massaging according to the basic version without heat treatment:

If the price of raw materials (pork) makes 200 rubles/kg. as of November 1, 2018, then the cost of the product makes $200 + 32.75 = 232.75 \text{ rubles} / \text{kg.}$

Next, let's add the cost of heat treatment in the heat chamber. After massaging, the semi-finished product should be moved to the "Kopti Sam 120" heat chamber (Fig. 3).

Smoking chamber features:

Cold and hot smoking; allows you to maintain the chamber temperature within 10-95 °C; convection inside the chamber evenly distributes smoke and evens out the chamber temperature; chamber volume - 120 l; 2.8 liter smoke generator; power consumption - 2.02 kW; single load of 15-50 kg.



Figure 3: "Kopti Sam 120" Heat Chamber

Duration of boiling and smoking of the semi-finished product in a heat chamber to obtain a smoked product from lumpy meat makes 40-80 minutes.

Electricity Costs

Specific Energy Costs

The capacity of the heat chamber is 140 kg / day or 3500 kg / month
 $(20 \cdot 7 \cdot 25 = 3500 \text{ kg / month})$.

Table 2: Economic Indicators of the Microwave Device Introduction for Heat Treatment in the Process of Lumpy Meat Massaging

Indicators	"Gambit-120" meat and massager vacuum and "Kopti Sam 120" heat chamber	Microwave unit (design model)
Book value, rub.	100000	77000
Production processes	massaging, vacuum brine, heat treatment	massaging, brining, EMFUHF treatment
Unit productivity, kg/h:	7	8
Power consumption, kW of drum drive pump vacuum heat chambers	0,6 0,55 kW· /m ³ h 2,02	1,85
Electricity consumed, kWh/kg		0,23
Total amount of operating costs, rubles / month	58054	40485,2
Total operating costs for the process, rub/kg	47,4	28,92
The price of raw materials, rubles/kg	200	200
Product cost, rubles / kg	247,4	229
Product sales price, rubles / kg	400	400
Profit, rub./kg	152,6	171
Volume of output, kg / month	1225	1400
Capital costs, rub. / (kg / month)	81,63	55,00
Economic effect, rub/month	$[(47,4 + 0,2 \cdot 81,63) - (28,92 + 0,2 \cdot 55)] 1400 = 33328$	
Profitability, %	61,68	74,67

However, we need to pass massaged raw materials of 49 kg / day or 1225 kg / month through the "Kopti Sam 120" heat chamber.
 $2.02 \text{ kW} \cdot 7 \text{ kg / h} \cdot 7 \text{ h} = 99 \text{ kW} \cdot \text{h / day} = 2474.5 \text{ kW} \cdot \text{h / month}$ [8]

Electricity Costs

$2474.5 \cdot 6 \text{ rubles / kW} \cdot \text{h} = 14847 \text{ rubles / month}$.

Other expenses: $(28764.4 + 800 + 14847 + 1666.7 + 2000) \cdot 0.05 = 2404 \text{ rubles / month}$.

General production expenses:

$(28764.4 + 800 + 14847 + 1666.7 + 2000 + 2404) \cdot 0.15 = 7572 \text{ rubles / month}$.

Total operation costs:

$28764.4 + 800 + 14847 + 1666.7 + 2000 + 2404 + 7572 = 58,054 \text{ rubles / month}$.

The cost of operation costs for the production of smoked products according to the basic variant.

$58054 \text{ rub} / \text{month} / 1225 \text{ kg} / \text{month} = 47.4 \text{ rub} / \text{kg}$.

The cost of smoked products according to the basic variant:

$200 + 47.4 = 247.4 \text{ rub} / \text{kg}$.

The results of technical and economic indicator assessment concerning a microwave unit use for heat treatment in the process of raw meat massaging in brine are summarized in table. 2. [9,10]

Conclusion

The economic effect of device use with a microwave energy source for heat treatment in the process of lumpy meat massaging as compared to the combined use of the meat massager "Gambit-120" and the Smokehouse "KoptiSam-120NPP" is 400 thousand rubles / year due to lower operating costs for the volume of output 16.8 tons per year. Profitability will be increased by 13%.

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