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Development of an Extra small machine for Making Fresh Pho based on Optimal Steaming Process

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Abstract— The article introduces an extra small fresh pho production machine based on the optimization of the heat impact process's parameters in steaming operation. The two most important quality characteristics of pho i.e. the toughness and surface roughness are closely related to the swelling process and the changing the viscosity of mixture water and powder during the steaming operation. In this study, the duration for the steaming process is reduced to 60 seconds compares to 90 seconds in the current pho making technology. The proposed design also reduces the size of the steam chamber and cooling mechanism. Therefore, an extra small machine with a size of 1000 mm in length, 500 mm in width, 350 mm in height which is suitable for restaurants and hotels can be made. The quality of pho is equivalent to that produced with a typical industry.

Keywords— Food production, Steaming, Vietnamese Pho, Machine design.

1. Introduction

Vietnamese fresh rice noodle has many types, such as "pho, bun, hu tieu, banh hoi, banh cuon, etc.", depending on the making technology and the rice material. Pho is one of the most famous type of Vietnamese noodle soups consisting of broth, rice noodle, meat, cilantro and onion, primarily made with either beef or chicken. It is convenient, easy to cook, delicious and a nutritionally rich product and is now great appraisal outside Vietnam.

Fresh pho is the quintessence of Vietnamese cuisine. Currently, fresh pho is currently produced on high-power machines. In other countries, such as USA, France, Korea, Japan, Taiwan, Australia, etc., pho is mostly imported from Vietnam and Thailand in a dried form. However, customers prefer fresh pho than dried one due to the different taste and how they taste when combining with other cooking ingredients. In order to directly produce fresh pho in restaurants and hotels, the machine must be small enough and have suitable power consumption to be installed and operated in these environments, while having the same quality as pho produced by the industry.

The rice that is used to make the pho must be dry, expansive and not sticky when cooked. The Vietnamese market has many types of rice, such as 504, Long Dinh, etc. The United States' market has 3 Con Voi, long grain rice, in Japanese market has Yume Toiro. Before making fresh rice noodle, the rice needs to be dipped in water to make it soft and easier to mill into powder. After milling, the rice powder goes through a steam machine to form into a long thin sheet and then cut into strands. Pho has a starch content of around 60%, protein content is from 7,42% to 11,11% and the amylose content is higher than 25% [1].

2. Materials and methods

Rice is collected from markets such as 504 and Long Dinh in Vietnam, the long grain rice in Mexican and American markets and Yume Toiro in Japan. The rice is dipped in the water for 6 hours and it is milled with 1:1.5 ratio (rice/water).

2.1 Parameter requirements

The size of the machine is restricted to be extra small, yet its capacity should be sufficient for at least 100 customers per day. The required machine specifications are given in Tables 1 and 2. The machine can be installed on a table and is also portable.

Table 1. Parameters considerations for product

Capacity	Length of Pho	Width of Pho	Thickness of Pho
5 kg/hour	160 mm	3 mm; 5 mm; 8 mm	0.5 ~ 1 mm

Table 2. Features of the extra small machine

Length	Width	Height	Material
1000 mm	500 mm	350 mm	SUS 316

2.2 Design of the extra small machine

In typical industrial machine design, the machine (and subsequently the steamer) size is too small to achieve the capacity of 5 kg/hour, otherwise it is bigger than the restricted size to achieve it. The reason for this dilemma is the lack of optimization of the steaming process in industry. Therefore, the goal of this research will be its optimization in order to meet the size restriction and capacity requirement simultaneously.

2.2.1 Proposed design

A proposed design is illustrated in Figure 1 for the machine to be extra small and suitable for hotel and restaurant installation.

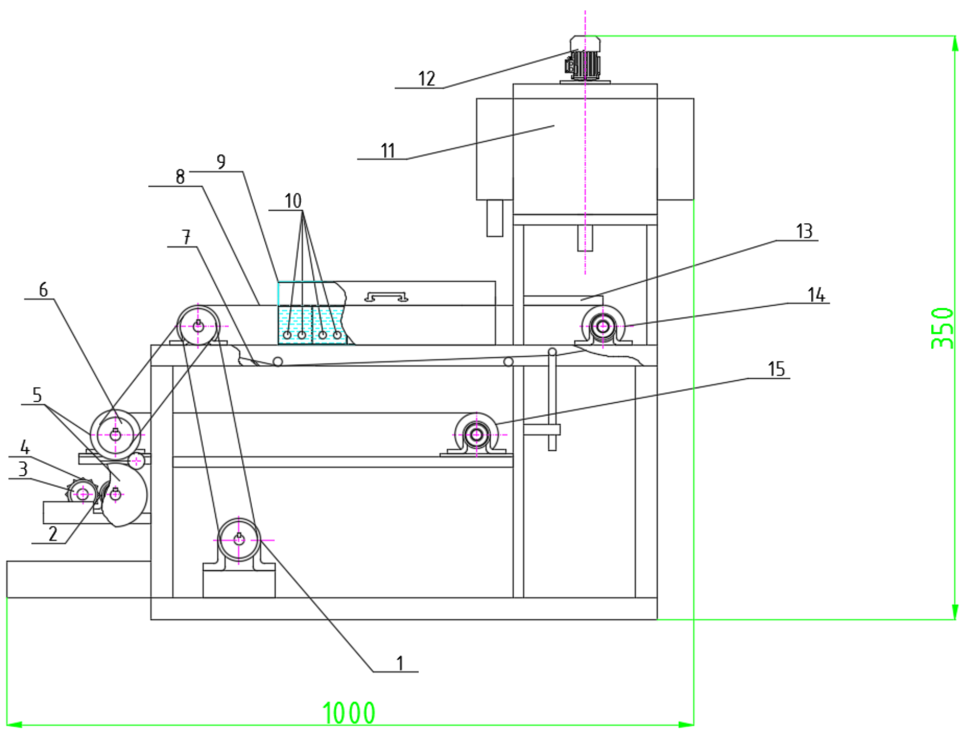

Figure 1 Schematic of the proposed design
1-Electric Motor, 2-Transition shaft, 3-Bearings, 4-Cutter, 5-Gear,
6-Pulley, 7-Sharp-edged bar, 8-Conveyor, 9-Steamer, 10-Resistor,
11-Mixing tank, 12-Electric motor, 13-Mold, 14-Bearings, 15-Net conveyor

Rice powder is poured into the mixing tank (11) and mixed by a motor (12), it is poured down into the mold

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(13) and the cloth conveyor carried it through the steam chamber (9) where water is boiled to 100°C by resistors (10). Under the cloth conveyor is a bar with the sharp edge (7) to detach the pho sheet from the cloth conveyor and transfer it to the net conveyor (15). Because the sheet does not stick to the net conveyor it fall down to the clothed stainless steel shaft (2), which contacts the cutter (4) mounted between two bearings (3) and rotates the cutter through friction, the pressing effect of the normal force pushes the cutting edge into the pho sheet and cuts it into strands. Fresh rice noodle after processing must have the following qualities: white, distinct smell of rice, elasticity and the geometry of the strip (strand noodle) is acceptable.

2.2.2 Heat transfer process in the steamer

Relationship between the swelling and viscosity of rice powder and steaming temperature

The amount of swelling and viscosity level of liquid rice flour in the steaming process affect the toughness and the roughness of the pho fiber when formed.

The swelling of liquid rice flour depends on temperature, and affects the physical and mechanical properties of Pho fiber, in particular, the swelling process deforms the surface of the Pho. If the amount of swelling exceeds the permissible limit, micro cracks appear on the surface of pho and the fiber breaks easily when contacting with the hot soup. In addition, deformation and cracks in pho due to swelling also affect its surface quality negatively. Therefore, the temperature of the steaming process must be within certain limits. Figure 2 shows the relationship between temperature and the amount of swelling [2]. The swelling factor dramatically increases beyond 90°C, and starts to affect the physical-mechanical properties and surface quality of pho negatively

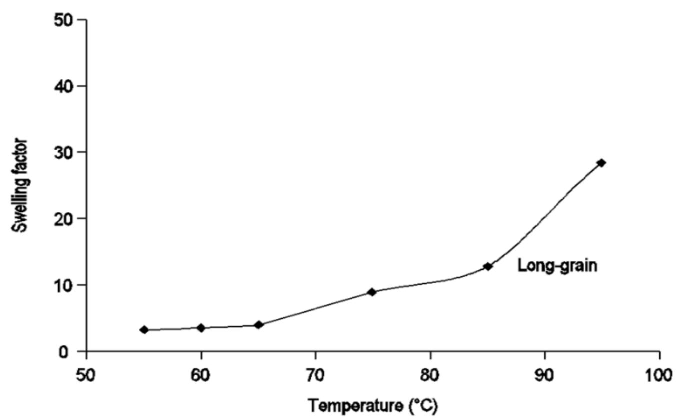


Figure 2 Relationship between swelling factor of long grain rice and temperature [2]

Relationships between viscosity and temperature are experimentally determined for three specific type of liquid flour: tapioca, the mixture of rice and tapioca and rice (long grain).

In Figure 3, viscosity is nearly unchanged at temperature up to 70°C, viscosity increases from 70°C and reaches the predicted maximum value at 90°C and continues to increase when the temperature is maintained for a period of less than 60 seconds. After exiting the steamer and undergoing the cooling process, the viscosity continues to increase, making Pho tougher and more flexible. Detailed descriptions of viscosity variation are given in Table 3.

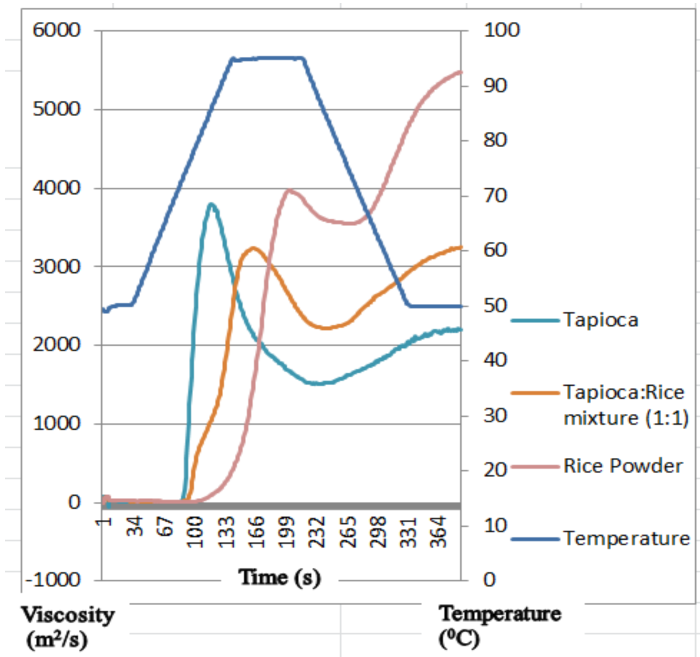


Figure 3 Relationship between viscosity of three flour types and temperature

Table 3 Viscosity properties of three flour types when increasing temperature

	Tapioca	**Rice, Tapioca mixture (1:1 ratio)**	**Rice**
Pasting Point	16*	23	29
Peak Viscosity	3799	3241	3976
Hold Viscosity	1506	2220	3549
Final viscosity	2200	3250	5485
Breakdown Point	2293	1021	427
Setback 1	694	1030	1936

*Unit: m^2/s

From the swelling factor and viscosity data, a temperature chart in Figure 4 for processing pho is proposed. Figure 4 describes a steaming cycle in which temperature is rapidly increased from 30°C to 90°C in the first 10 seconds, (the Pho has been moved 66mm during this time), the temperature is kept constant at 90°C for the next 50 seconds, this is stage two (the pho has been moved 334mm during this time), then the pho is subjected to a rapid cooling process in which temperature is decreased from 90°C to 30°C during 10 seconds, this is stage three. After being cooled, pho is moved to the next process.

Heat transfer analysis

Parameter values for the analysis are given in Table 4. The purpose of heat transfer analysis is to optimize all parameters that affect the final power requirement of steaming process, reducing power consumption while speeding up the steaming process.

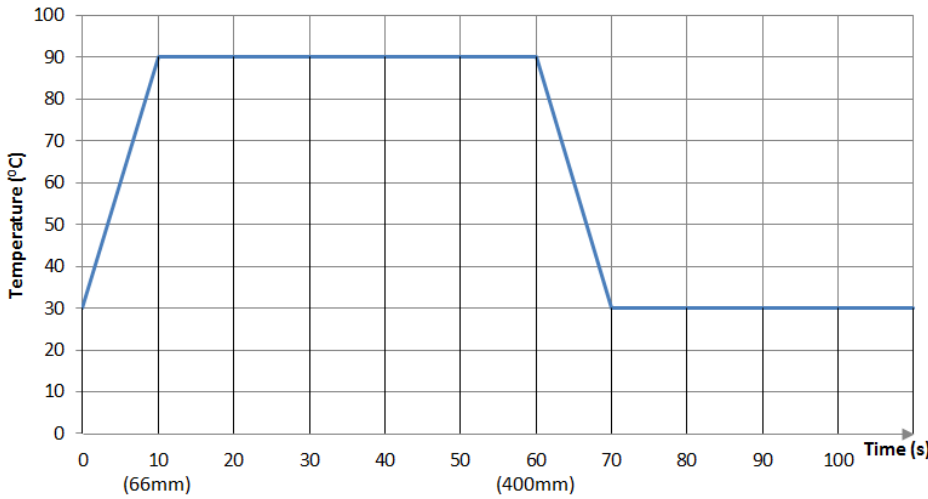


Figure 4 Temperature chart for steaming and cooling of pho

Table 4 Specifications for heat transfer analysis

No.	Parameter	Annotation	Unit	Value
1	Capacity	D_1	kg/hour	5
2	Conveyor's length	L	mm	400
3	Conveyor's width	W	mm	200
4	Cycle time	τ	second	60
5	Rice powder's density	ρ_p	kg/m^3	1020
6	Input temperature of rice powder	t_1	^{0}C	30
7	Output temperature of pho	t_2	^{0}C	90
8	Rice powder: water mixing ratio	φ	Dimensionless quantity	2:3
9	Humidity of rice powder	ω	%	15
10	Initial humidity of pho	ω_1	%	66
11	Final humidity of pho	ω_2	%	62
12	Heat capacity of pho	C_p	kJ/kg.K	2.76
13	Latent heat of water at atmospheric pressure	r	kJ/kg	2350
14	Density of steam at atmospheric pressure	ρ_s	kg/m^3	0.59
15	Temperature of ambient air	t_a	^{0}C	30
16	Velocity of ambient air	ω_a	m/s	2
17	Height of steam chamber	H	m	0.3
18	Thermal conductivity coefficient of steam chamber's insulation	λ_i	W/mK	0.02
19	Thickness of insulation	δ_i	m	0.025
20	Thermal conductivity coefficient of steam chamber's wall	λ_w	W/mK	40
21	Thickness of steam chamber's wall	δ_w	m	0.003

Equations for the analysis is [3] and obtained parameter values are given in Table 5

Table 5. Results of heat transfer analysis

No.	Parameter	Formula	Unit	Value
1	Conveyor's velocity	$\omega = \frac{L}{\tau}$	mm/s	6.66
2	Mass of pho on conveyor	$G = ((D_1 \times 1000)/60).\tau$	g	83.33
3	Volume of pho on conveyor	$V = \frac{G}{\rho_p}$	m^3	0.0000817
4	Thickness of pho on conveyor	$h = \frac{V}{S}$	mm	1.277
5	Sensible heat heating	$Q_s = D_1.C_p.\Delta t$	kW	0.23
6	Mass flow of water in pho at the input of conveyor	$W_1 = D_1.\omega_1$	kg/hour	3.3
7	Mass flow of rice powder in pho at the input of conveyor	$R = D_1 - W_1$	kg/hour	1.7
8	Mass flow of pho at the output of conveyor	$D_2 = \frac{R}{1-\omega_2}$	kg/hour	4.47
9	Mass flow of water separated from pho	$\Delta D = D_1 - D_2$	kg/hour	0.53
10	Latent heat for separate water in pho	$C = \Delta D.r$	kW	0.346
11	Total heat for heating pho	$Q_P = Q_s + Q_L$	kW	0.576
12	Physical parameters of air at t_a=30°C: Thermal conductivity coefficient\Kinematic viscosity\Prandtl number	λ\ν\Pr	(W/mK)\(m^2/s)\(Dimensionless quantity)	0.0276\16x10^6\0.701
13	The equivalent diameter of chamber	$d = \frac{4A}{U} = \frac{4.H.W}{(H+W).2}$	m	0.24
14	Reynold number	$Re = \frac{\omega_a.d}{\nu}$	Dimensionless quantity	30000
15	Nusselt number	$Nu = 0{,}28.Re^{0{,}6}.Pr^{0{,}36}\left(\frac{Pr_f}{Pr_w}\right)^{0{,}25}.\varepsilon_\varphi$	Dimensionless quantity	119.64
16	Heat transfer coefficient of air (*)	$\alpha_a = \frac{Nu.\lambda}{d}$	W/m^2K	13.76
17	Heat transfer coefficient from water in chamber to air (**)	$k = \frac{1}{\frac{1}{\alpha_w}+\frac{\delta_w}{\lambda_w}+\frac{\delta_i}{\lambda_i}+\frac{1}{\alpha_a}}$	W/m^2K	0.756
18	Overall area of chamber	F=2. (W+H). L+2.W.H	m^2	0.52
19	Heat loss from chamber to ambient air	$Q_{loss} = k.F.\Delta t$	W	27.51
20	Overall heat input	$Q = Q_P + Q_{loss}$	kW	0.6035
21	Steam flow for heating	$G_s = \frac{Q}{r}$	kg/hour	0.9245
22	Steam flow leaks	δG=ε.S.δP	kg/hour	1
23	The overall steam flow	$G_O = (1+\eta).G_s$	kg/hour	1.9245

24	Volume flow of steam	$V_O = \frac{G_O}{\rho_s}$	m^3/hour	3.261

(*) The effect of the heat flow direction is ignored and air is assumed to be blown vertically to the chamber axis

(**) Because heat transfer coefficients of water in the steam chamber is very high, we ignore the heat resistance of water, i.e., $\frac{1}{\alpha_w} \approx 0$

Table 6 shows the time for heating pho is 10s (Stage one in Figure 4)

Table 6. Process parameters of stage one

No.	Parameter	Formula	Unit	Value
1	Heat input	$Q_1 = C$	kW	0.23
2	Steam flow	$G_1 = \frac{Q_1 + 0.5Q_{loss}}{r} \times 3600 + \frac{\delta G}{2}$	kg/hour	0.8735
3	Volume flow of steam	$V_{O1} = \frac{G_1}{\rho_s}$	m^3/h	1.48
4	Total distance of stage 1	$L_1 = 10\omega$	mm	66

Table 7 shows the time for cooking pho is 50s (Stage two in Figure 4)

Table 7. Process parameters of stage two

No.	Parameter	Formula	Unit	Value
1	Heat input	$Q_2 = Q_s$	kW	0.346
2	Steam flow	$G_1 = \frac{Q_2 + 0.5Q_{loss}}{r} \times 3600 + \frac{\delta G}{2}$	kg/hour	1.052
3	Volume flow of steam	$V_{O1} = \frac{G_1}{\rho_s}$	m^3/h	1.7816
4	Total distance of stage 1	$L_2 = 50\omega$	mm	334

Table 8 shows process parameters water boiling (from 30^0C to 100^0C)

Table 8. Technical parameters of water boiling process

No.	Parameter	Formula	Unit	Value
1	Density of water at ambient temperature	ρ_w	kg/m^3	980
2	Heating time	t_h	seconds	600
3	Maximum water volume	V	m^3	$5x10^{-3}$
4	Specific heat of water	C_{pw}	kJ/kg.K	4.187
5	Temperature change	$\delta T = 100 - 30$	^{0}K	70
6	Total energy supply	$Q = V.\rho_w.C_{pw}.\delta T$	kJ	1430.31
7	Capacity of electrical resistor	$P = Q/t_h$	kW	2.38

Simulation and experiment for heat transfer process

In order to ensure the design size and productivity specified in Tables 1 and 2. Thermal distribution on the surface of pho must follow the graph in Figure 4. The heat distribution on the pho surface depends on many factors, of which most important two factors are the velocity of motion and the area exposed to heat. In order to visualize the heat distribution, a diagram is assumed as in Figure 5 and used for computer simulation.

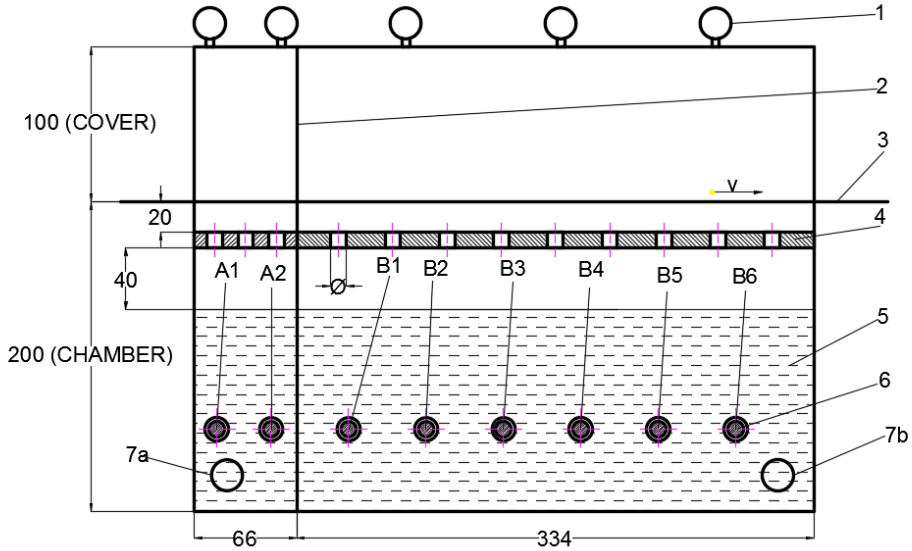


Figure 5 Structures of the steam chamber used for computer simulation of heat transfer. (1) Steam thermometer; (2) Seperator plate; (3) Cloth conveyor; (4) Plate with holes; (5) Water; (6) Resistor; (7) Water thermometer

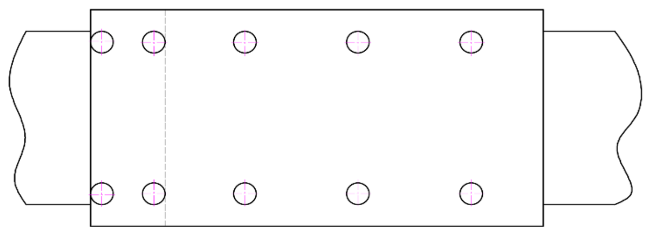
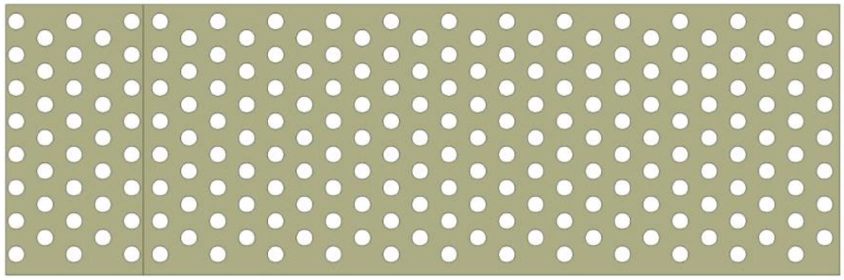
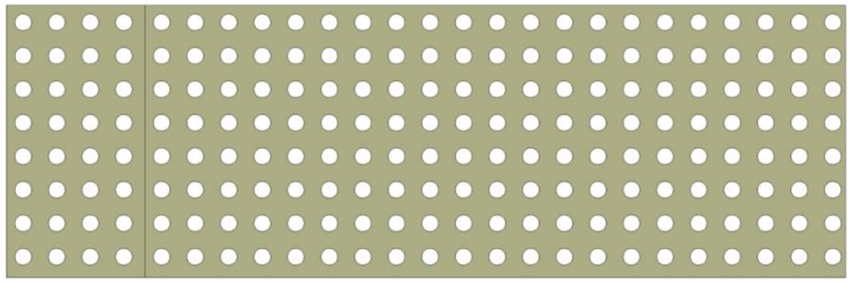


Figure 6 Arrangement of ten temperature gauges (top view)

In order to ensure uniform heat distribution on the surface of pho, it is necessary to study the size and distribution of the holes on the plate (number 4 in Figure 5). The heat distribution on the surface of the pho was simulated with holes from 2 to 10 mm arranged in two ways: staggered and parallel along the length of the plate, as shown in Figure 7. Center distance L between holes on the plate (number 4 in Figure 5) is equal to 2d (where d is holes diameter).



Staggered arrangement



Parallel arrangement

Figure 7 Two patterns of hole arrangement

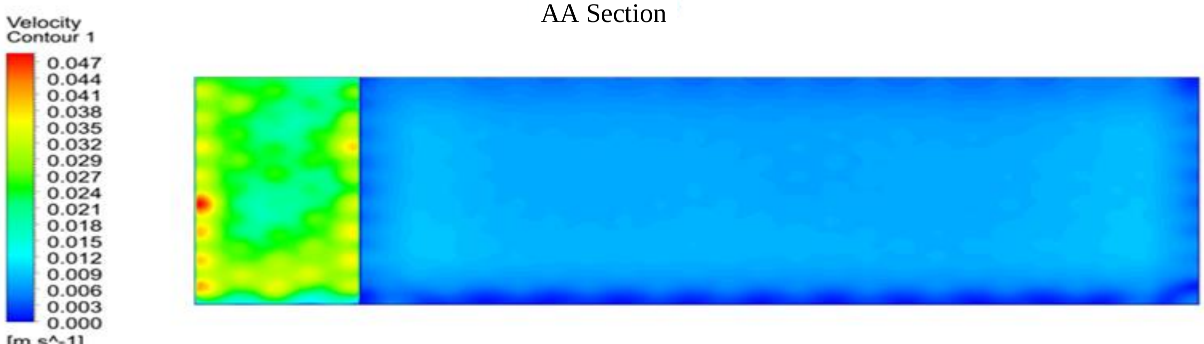
Input information for simulation are given in Table 9.

Table 9 The parameter values used for computer simulation

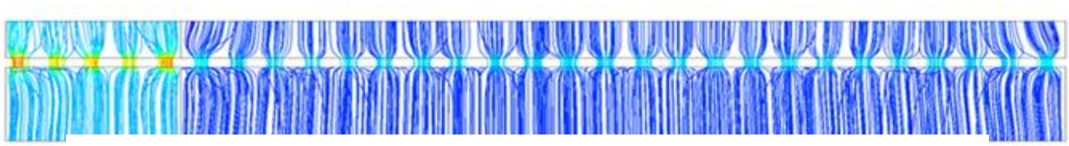
Parameters	Results
Hole diameter	5mm and 8mm
Model size	Figure 5
Hold arrangement styles	Figure 7
Steaming fluid conditions	100^0C saturated vapor
Ambient temperature	30^0C
Mass flow rate inlet at 2 sections	Table 6 and Table 7

Simulation is performed on the software ANSYS FLUENT 18 and the results are given in Figure 8.

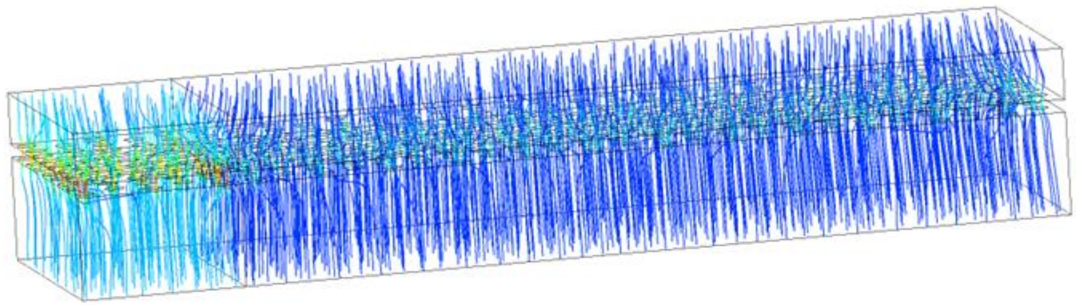
AA Section



Velocity contour at AA cross section (staggered arrangement, 8mm diameter holes)



Side streamline view



Iso streamline view (staggered arrangement, 8mm diameter holes)

Figure 8 Simulation results.

In order for the temperature distribution in pho to follow the profile given in Figure 4, it is necessary to study the distribution and power of resistors in each region A (6A1 and 6A2) and B (6B1, 6B2, 6B3, 6B4, 6B5 and 6B6) in Figure 5. In this simulation, the number of resistors in each area is chosen according to the size of that area, the total power consumption has been determined in Table 8. The resistors are placed and denoted as shown in Figure 5, and ten temperature gauges are mounted on the cover as shown in Figure 6 to determine the heat distribution of the chamber in the vertical and horizontal directions. After the simulation, the power distribution is determined as shown in Table 10.

Table 10 Power distribution of resistor in regions A and B

<table>
<tr><th>Region</th><th colspan="6">Power (kW)</th></tr>
<tr><td rowspan="2">A</td><td colspan="3">A1</td><td colspan="3">A2</td></tr>
<tr><td colspan="3">0.68</td><td colspan="3">0.68</td></tr>
<tr><td rowspan="2">B</td><td>B1</td><td>B2</td><td>B3</td><td>B4</td><td>B5</td><td>B6</td></tr>
<tr><td>0.17</td><td>0.17</td><td>0.17</td><td>0.17</td><td>0.17</td><td>0.17</td></tr>
</table>

The flow uniformity index* for the different hole diameter is given in Table 11.

Table 11 Flow uniformity index

	Parallel arrangement	**Staggered arrangement**
Hold diameter, 5mm	0.686	0.707
Hold diameter, 8mm	0.716	0.726

The simulation results in Figure 8 shows that 8mm holes arranged in staggered pattern are the best arrangement solution since it results in the highest flow uniformity index.

2.3 Kinematics

2.3.1 Input Parameters

Table 12 Input parameters for kinematics calculation

No.	**Parameter**	**Annotation**	**Unit**	**Value**
1	Conveyor's velocity	ω	m/s	6.66×10^{-3}
2	Shaft Diameter (number 14 in Figure 1)	d	mm	60

2.3.2 Output Parameters

Table 13 Result of kinematics calculation [4]

Parameter	Formula	Unit	Value
Rotational speed of driving shaft	$n = \frac{60000\omega}{\pi d}$	rpm	2.12

2.4 Dynamics

2.4.1 Input Parameters

The major parameters for calculating the machine power requirements are given in Table 14. The results are given in Table 15.

Table 14 Input parameters for dynamics calculation

No.	Parameter	Annotation	Unit	Value
1	Belt center distance (number 8 in Figure 1)	D_B	m	0.82
2	Belt width (number 8 in Figure 1)	W	m	0.2
3	Belt thickness (number 8 in Figure 1)	t_B	m	0.001
4	Belt material's specific weight [5]	ρ_B	kg/m^3	1600
5	Friction coefficient	μ_T	Dimensionless quantity	0.33
6	Gravitational acceleration	g	m/s^2	9.81
7	Shaft diameter (number 14 in Figure 1)	d	m	0.06
8	Efficiency of timing belt	η_T	Dimensionless quantity	0.95
9	Width of pho on conveyor	w_p	m	0.16
10	Thickness of pho on conveyor	h	m	0.001277
11	Rice powder's density	ρ_p	kg/m^3	1020
12	Rotational speed of shaft	n	rpm	2.12

2.4.2 Output Parameters

Table 15 Results for dynamics calculation

No.	Parameter	Formula	Unit	Value
1	Length of Pho on steam conveyor	$L_p = \frac{4}{3}D_B + \frac{\pi d}{2}$	m	1.19
2	Belt total length	$L_p = 2D_B + 2(\frac{\pi d}{2})$	m	1.83
3	Mass of Pho on steam conveyor	$m_p = m_1 + m_2 = \rho_p \times h \times w_p \times L_p$	kg	0.25
4	Mass of Belt	$M_B = \rho_B \times t_B \times W \times L_B$	kg	0.59
5	Effective pull force [6]	$F_U = \mu_T \times g \times (m_1 + m_2 + m_B)$	N	2.72
6	Torque of driving shaft	$T = F_U \times \frac{d}{2}$	Nm	0.0816
7	Power requirement [7]	$P = \frac{T \times n}{9.55\eta}$	W	19

3. Experiment

3.1 Selection of rice

Rice grain is the base ingredient for making Pho. It has a long appearance, and highly expansive after cooking, the rice used to make Pho must be dry, not sticky rice. For the experiment, the brands are used as from southern Vietnam, 504; from US, Sarita and from Japan, Yume Toiro. Ten kg are used for each type of rice

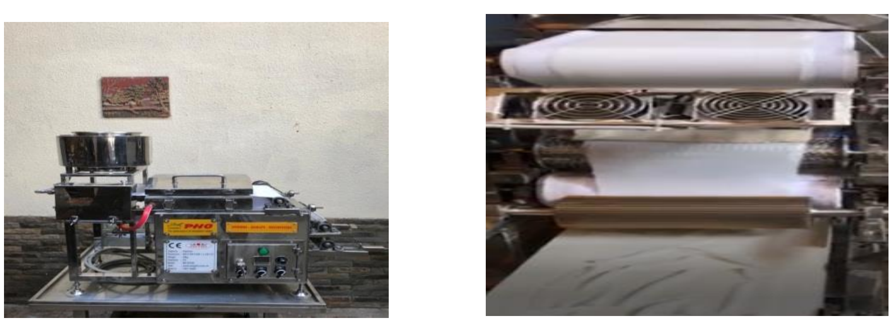
3.2 Powder Making

First, the rice is dipped in the water for 6 hours. The rice powder is prepared by wet milling using the machine in Figure 9. After that, the powder is mixed by the mixer, which is mounted on the machine. Process parameters are given in Table 16.

Figure 9 Rice milling machine

3.3 Making Pho with the proposed machine

On the machine, the steaming temperature is set and controlled based on the value obtained from calculation and computer simulation. The speed of the conveyor is varied using a frequency converter.



(a) (b)

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(c)

(d)

Figure 10. (a) The prototype machine;
(b) The fresh Pho is being produced by the small machine
(c) Fresh Pho from rice 504
(d) Fresh Pho from the market

Table 16 Process parameters

	Area 1	**Area 2**	**Area 3**
Temperature range	30-90^{0}C	90^{0}C	90-30^{0}C
Cycle time	10 seconds	50 seconds	10 seconds

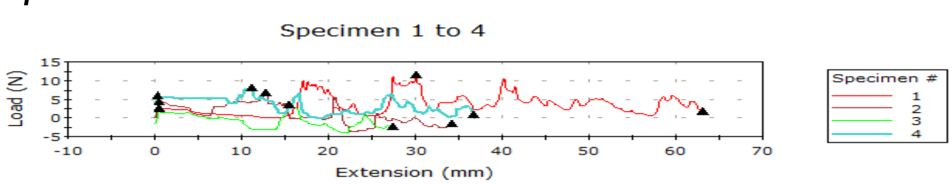
4. Evaluation of product quality

4.1 Testing the tensile strength of the product

The experiment set-up for measuring tensile strength of Pho is shown in Figure 11. The result is given in Figure 12 and Figure 13.

Figure 11 Tensile strength test machine.

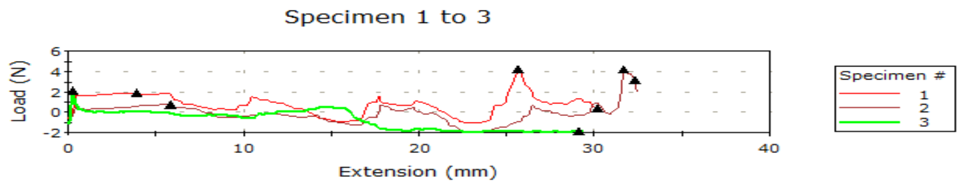
4.1.1 Properties of Pho on the market



	Specimen label	Maximum Load (N)	Tensile stress at Maximum Load (MPa)
1	soi pho 1	6.83988	0.07124875
2	soi pho 2	3.80934	0.039680625
3	soi pho 3	8.10206	0.084396458
Mean		6.250426667	0.065108611
Standard Deviation		2.206230422	0.022981567

Figure 12 Measurement graph and results for Pho.

4.1.2 Properties of pho made from 504 rice



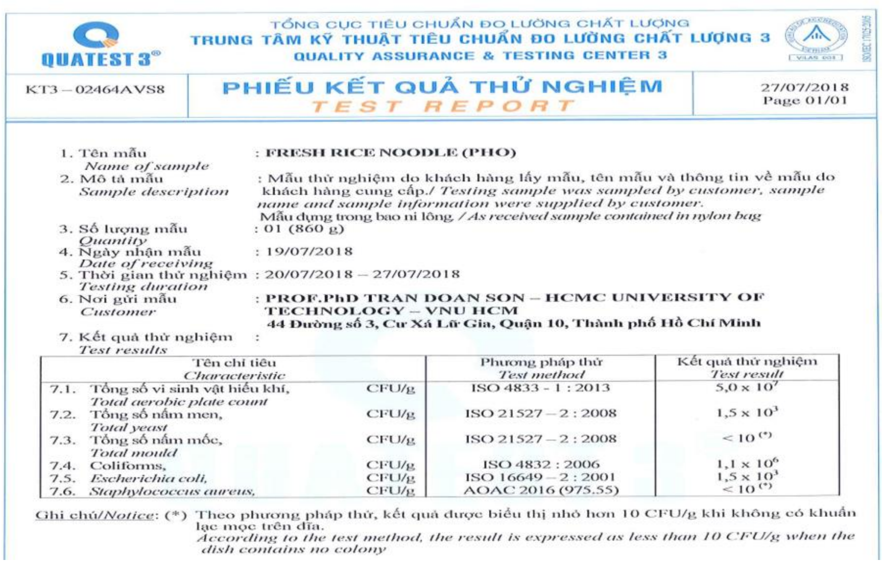
	Specimen label	Maximum Load (N)	Tensile stress at Maximum Load (MPa)
1	soi pho 1	4.24695	0.044239063
2	soi pho 2	4.21475	0.043903646
3	soi pho 3	2.11559	0.022037396
Mean		3.525763333	0.036726701
Standard Deviation		1.221352051	0.012722417

Figure 13 Measurement graph and results of 504

According to the test result, both types of Pho have good elasticity, but the one made from 504 rice has only half the toughness compared to pho available on the market.

4.2 Testing the bacteriology of the product

Figure 14 shows the result of the bacteriological test. According to the food safety standards of the Vietnam Ministry of Health, Pho produced from the proposed machine is confirmed to be sufficiently safe for use.



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TỔNG CỤC TIÊU CHUẨN ĐO LƯỜNG CHẤT LƯỢNG
TRUNG TÂM KỸ THUẬT TIÊU CHUẨN ĐO LƯỜNG CHẤT LƯỢNG 3
QUALITY ASSURANCE & TESTING CENTER 3

KT3 – 02464AVS8

PHIẾU KẾT QUẢ THỬ NGHIỆM
TEST REPORT

27/07/2018
Page 01/01

1. Tên mẫu / *Name of sample*: FRESH RICE NOODLE (PHO)
2. Mô tả mẫu / *Sample description*: Mẫu thử nghiệm do khách hàng lấy mẫu, tên mẫu và thông tin về mẫu do khách hàng cung cấp./ *Testing sample was sampled by customer, sample name and sample information were supplied by customer.* Mẫu đựng trong bao ni lông / *As received sample contained in nylon bag*
3. Số lượng mẫu / *Quantity*: 01 (860 g)
4. Ngày nhận mẫu / *Date of receiving*: 19/07/2018
5. Thời gian thử nghiệm / *Testing duration*: 20/07/2018 – 27/07/2018
6. Nơi gửi mẫu / *Customer*: PROF.PhD TRAN DOAN SON – HCMC UNIVERSITY OF TECHNOLOGY – VNU HCM, 44 Đường số 3, Cư Xá Lữ Gia, Quận 10, Thành phố Hồ Chí Minh
7. Kết quả thử nghiệm / *Test results*:

Tên chỉ tiêu / *Characteristic*		Phương pháp thử / *Test method*	Kết quả thử nghiệm / *Test result*
7.1. Tổng số vi sinh vật hiếu khí, *Total aerobic plate count*	CFU/g	ISO 4833 - 1 : 2013	$5,0 \times 10^7$
7.2. Tổng số nấm men, *Total yeast*	CFU/g	ISO 21527 – 2 : 2008	$1,5 \times 10^3$
7.3. Tổng số nấm mốc, *Total mould*	CFU/g	ISO 21527 – 2 : 2008	$< 10^{(*)}$
7.4. Coliforms,	CFU/g	ISO 4832 : 2006	$1,1 \times 10^6$
7.5. *Escherichia coli,*	CFU/g	ISO 16649 – 2 : 2001	$1,5 \times 10^3$
7.6. *Staphylococcus aureus,*	CFU/g	AOAC 2016 (975.55)	$< 10^{(*)}$

Ghi chú/*Notice*: (*) Theo phương pháp thử, kết quả được biểu thị nhỏ hơn 10 CFU/g khi không có khuẩn lạc mọc trên đĩa. *According to the test method, the result is expressed as less than 10 CFU/g when the dish contains no colony*

Figure 14 Microbiology test result.

5. Result and discussion

Extra small Pho production equipment has been designed and developed to suit the restaurant and hotel environment. Comparing to the superheated steam treatment [8, 9], the steaming solution presented in this research uses steam at atmospheric pressure to steam pho, so there is no need to build up pressure within the chamber and as such more suitable for hotel and restaurant, where fresh noodle should be served as soon as possible after customers make the order. In addition, pressurized equipment must undergo stricter quality control and safety check, and even then, users and customers are still afraid of being close to a pressure equipment, conflicting with the goal of this research of targeting the hotel and the restaurant user group. This research provides an innovative solution, in that there has been no research on the heat transfer optimization solution mentioned in this paper.

6. Conclusions

The extra small Pho production equipment is designed and developed based on studying the impact of heat transfer during the steaming process. The qualities of the Pho that need be to ensure are its toughness and smoothness, which depend on the swelling and change in viscosity of the material during steaming. Determining the initial and final viscosity is important to shorten the steaming time and steamer's size.

The developed small-sized machine for making Pho is suitable to place in the restaurants and uses an electrical source with 220V or 110 V voltage (1 phase) and 2.4 kW of power consumption and can make Pho from a variety of rice available in the global market.

Pho produced by the proposed small-sized machine is ensured to have sufficient textural, mechanical properties and safe microbiological content.

7. References

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