TECHNICAL UNIVERSITY OF CLUJ-NAPOCA

ACTA TECHNICA NAPOCENSIS

Series: Applied Mathematics, Mechanics, and Engineering
Vol. 65, Issue II, June, 2022

THE INFLUENCE OF WOOD CRIBS SHAPE ON THE MASS LOSS AND TEMPERATURE VARIATION IN ENCLOSED SPACES

Ion ANGHEL, Alexandru-Florin CHIOJDOIU, Mădălin Adrian PETRACHE, Sebastian VRABIE

Abstract: *The shape of wood cribs has an important influence both on the mass loss and on the temperature values recorded inside the fire compartment. Thus, in the case of the wood crib with the highest porosity, both the total mass loss values and the sudden mass loss values measured at the time of wood crib collapse are maximal. Also, the value of the maximum temperature recorded in the fire compartment as well as the burning rate increases with the rise of the crib porosity.*
Key words: *porosity; mass loss; temperature.*

1. INTRODUCTION

Wood cribs are often used in experiments as an ignition source because they have a simple structure, the value of the surface exposed to fire is high and the burning behavior is close to the real fire development inside a room. *Zhang et al.* (2015) [1-2] have found that cross-thermal radiation released by wood cribs baguettes allows their burning to be sustained without external thermal flow.

Dhurandher et al. (2017) [3] have demonstrated that approximately 54 % of the energy generated from the burning of wood crib within a room, with a door type ventilation opening, leads to the heating of the walls by radiative and convective heat transfer, approximately 25 % of the energy is released by convection, through the door type ventilation opening, approximately 16% of the energy is heating the gases inside the room and approximately 5% of the energy is dissipated through the door type ventilation opening in the form of radiation. Because the heat transfer to the walls of the room is the highest in case of fire, the construction's structural security is significantly threatened. *Cioca et al.* (2012) [4] have developed a methodology for assessing fire risk, given that in an enclosed space, a small fire can represent a very high hazard in terms of producing a combustible atmosphere, which is equivalent to the initiation of an explosion.

Beyreis et al. (1971) [5] have observed a good correlation between the convective heat transfer coefficient values of the flames and hot gases resulting from the tests, 17.02 – 102.14 W/m^{2}K, compared to the values actually observed for the generalized combustion occurring in rooms, 19.86 – 87.95 W/m^{2}K.

The heat transfer coefficient value decreases rapidly as the distance from the fire outbreak increases, in the cases analyzed by *Anderson et al.* (2021) [6]. The value of 11.5 KJ/g of the wood cribs convective combustion heat, resulting from the measurement, in the fire growth phase, was used by *Heskestad* (2006) [7] to update the speed and temperature equations of the combustion gases from the composition of the upper layer formed at the level of the room ceiling.

Gupta et al. (2021) [8] found that there are two regimes that define the burning dynamics of a wood crib based fire on the total mass transfer number, B_T, meaning controlled fuel regime and

Received: 31.05.22; **Similarities**: 09.06.22: **Reviewed**: 15.06./17.05.22: **Accepted**:20.06.22.

controlled impulse regime. If the adiabatic mass transfer number, B_A, is less than 1, the convective heat flow from the flames is insufficient to sustain combustion and the flames will be extinguished. If condition $B_T > 1$ is met, fire extinction does not occur, with cross-thermal radiation emitted by the wood crib, providing an additional amount of heat required for fuel pyrolysis. The radiative heat flux released from the material subject to combustion to the material not yet affected by combustion ranges from 60-80 $\mathrm{KW/m^2}$ in the case of stacks characterized by a high porosity level, as tested by *Thomas* (1967) [9]. The thermal flow is a very important parameter, *Bjørge et.al* (2018) [10] noting that a thermal insulation of 50 mm thickness represents a passive protection following the action of a flow of 350 $\mathrm{W/m^2}$. Using the assumption that the porosity of wood cribs is constant, has been validated by *Croce et al.* (2005) [11] a method for scaling wood crib fires and a method for scaling wood palet fires by *Li et al.* (2017) [12] using model scale of 1/2-sized and 1/4 sized wood crib / palet.

Keshavarz et al. (2012) [13] and *Suzuki et al.* (2000) [14] have found that the absorption of energy required to evaporate existing water in the wood mass, cold air and air humidity contribute to reducing the severity of fire initiation and the rate of propagation. *Rush et al.* (2021) [15] observed that the low value of energy released into the fire compartment environment is accentuated by the high height between the top of the wood crib and the ceiling of the room, respectively by the vent. In poor ventilation conditions, *Zhang et al.* (2015) [1] has found that the highest values of loss in mass and CO concentration are obtained compared to good ventilation conditions. Under different ventilation conditions, the maximum flame temperature is in the range of 850-900 °C and the temperature recorded in the center of the wood crib is in the range of 1063-1126 °C, with these parameters being poorly influenced by the ventilation conditions. *Dhurandher et al.* (2019) [16] noted that the sudden opening of a fire compartment door at different times leads to a percentage increase in mass loss of wood cribs of 86 %, at 960 s, 116 % at 1600 s and 154 % at 2200 s after ignition. The heat flow values increase rapidly by reaching maximum values at the ceiling level of 8 - 9 $\mathrm{KW/m^2}$, the upper zone of 6.5 - 7 $\mathrm{KW/m^2}$ and the lower zone of 1.5 - 1.6 $\mathrm{KW/m^2}$. *Diab et al.* (2020) [17] have found, in a small-scale experiment that, with the increase in the number of baguettes on each layer, from 3 to 7, the burning rate increased by 1 to 1.3 times, the propagation rate was 0.92 to 1.66 times higher, the absolute temperature in the continuous flame area has increased by 0.99 to 1.2 times more and the average height of the flame has increased by 1 to 1.69 times more under the fire whirlpool (obtained by introducing air through an orifice in each corner of a parallelepiped device, with closed sides, in which a wood crib is placed) compared to the free burning of the wood crib. *Xu et al.* (2008) [18] have noted that the burning rate can be governed by the surface of the wood baguettes which burn, the maximum flow of air and combustion products circulating through the openings of the wood crib, and the maximum amount of oxygen available in the room. The product of the burning rate [kg/s] and the effective heat of combustion [MJ/kg] determines the HRR (heat release rate) parameter, with its maximum value describing quantitatively the magnitude of the fire intensity. The mass loss rate of a wood crib can be calculated as the product of the fire propagation velocity [cm/s] and the bulk fuel density [$\mathrm{kgm^{-3}}$], *Thomas et al.* (1964) [19] obtaining values in the range $5 - 9\ \mathrm{mgcm^{-2}s^{-1}}$.

The increase in the fire load value, obtained by increasing the length of the baguettes, and the wood crib mass influence the way in which the wood cribs burn, the maximum temperature obtained at the room ceiling being directly proportional to the increase in the mass of the wood cribs. Comparing the ceiling temperature values from the burning of the highest mass wood crib in the small-scale experiments carried out by *Mustafa et al.* (2013) [20], with limited ventilation, 10 air changes per hour, with a value of about 500 °C, during experiments on a natural scale, under free ventilation conditions, with a fuel load of 15 $\mathrm{kg/m^2}$, approximately the same temperature was recorded. *Smith et al.* (1970) [21] has developed an equation describing the average burning rate of wood cribs, having baguettes sizes between 30 cm and 200 cm, which is directly proportional to the mass loss rate [kg/s] and inversely proportional to the horizontal cross-section area of the vertical openings of the wood crib [m^2], surface area of wood exposed to fire [m^2] and wood crib height [m].

Rios et al. (1967) [22] have found that the flame spread rate and the depth of the burning zone increase as the wind speed increases.

Matvienko et al. (2022) [23] have noted that the reduction in ignition time is directly proportional to the increase in wind speed. According to the experiments carried out by

McAllister et al. (2016) [24-25], the wood cribs made of thicker baguettes, of 1.27 cm, showed an increase in the burning rate as the wind speed increased, taking values in the range of 6.5 % to 61.5 %, while those consisting of thinner baguettes, of 0.64 cm, showed a decrease in the burning rate as wind speed increases, taking values in the range of 36.7% to 60.6%. According to the results obtained by *Thomas et al.* (1965) [26], increasing the wood crib width (from 30 cm to 61 cm, the length being 90 cm) increases the fire spread rate (from 0,049 cm/s to 0,083 cm/s), the mass loss rate being directly proportional to the ratio between the total heat transfer speed and the surface unit. According to experiments carried out by *Weng et al.* (2015) [27], the increase in the separation distance between wood cribs and the increase in the number of baguettes enhances the efficiency of combustion due to the inflow of a larger volume of air. The variation of the radiative heat flux calculated with an empirical model for a single wood crib is similar to the variation of experimental data in the case of the flame fusion resulting from the burning of several wood cribs.

Trevits et al. (2002) [28] noted that the firefighting efficiency was increased by the relief of water over the entire surface of the burning materials, with a minimum value of the pipe pressure of 1.38 to 2.07 bars and the flow rate of 0.76 to 0.95 L/s, according to *Scheffey et al.* (1991) [29]. *Rappsilber et al.* (2019) [30] has found that the reduction in the burning area results in a decrease in HRR values, the total heat released is directly proportional to the mass loss. Also, *Noaki et al.* (2018) [31] has found that decreasing the water discharge distance increases the extinguish efficiency by using the spray jet compared to the compact jet.

The objective of this work is to analyze the influence of the wood cribs shape on the way in which burning occurs in a confined space.

2. EXPERIMENTAL PROCEDURE

In this article, the authors present a summary of experimental results on the influence of the geometry of wood cribs on their mass loss and temperature recorded in a confined space.

The experiments were carried out on a natural scale by *Petrache* (2021) [32] together with the co-authors of this work in the test area of the *Fire Behavior Laboratory* of the *Fire Officers Faculty*, shown in fig. 1.

Fig. 1. Test room

In the tests, 3 kinds of wood cribs were used, made up of baguettes, measuring 5 x 5 x 60 cm, arranged at different distances from each other, both horizontally and vertically. The wood cribs were placed, one at a time, in the center of the test room, as shown in fig. 2.

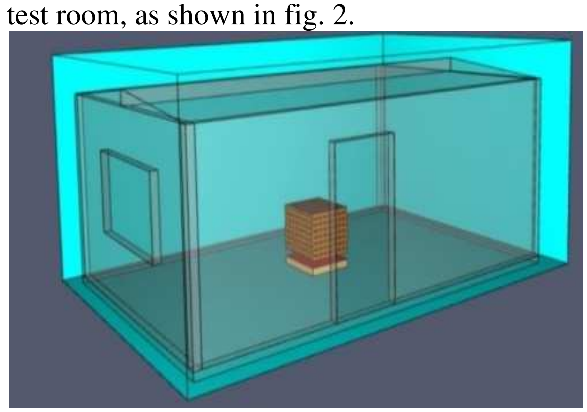

Fig. 2. Method of arrangement of the wood crib during combustion tests

The same ventilation conditions were also used during the combustion tests. Thus, as shown in fig. 3, both the side door (the opening surface of which is 1.70 m^2) and the two front windows (the opening surface of which is approximately 1.20 m^2) were kept open, at the same time.

Fig. 3. Configuration of the ventilation openings: a) non-side windows; b) side door.

The wood cribs are made of fir wood baguettes. Use the density value of the fir wood of 0.4 g/cm^3, and taking into account that the volume of one baguette is 1500 cm^3, this gives a weight of 600 g. The calorific power of the fir wood has a value of 4.31 kWh/Kg. From the data obtained so far, one can estimate that the fuel load of a baguette is 2.586 J.

According to fig. 4, ***the wood crib – model 1*** consists of 12 rows of baguettes, arranged 6 on each row, the distance between two adjacent baguettes, situated on the same layer, being 5 cm. The distance between the first, respectively the last, baguette of a row and the side faces of the wood crib, located in the immediate vicinity of the baguettes is 2.5 cm.

Thus, taking into account that ***the wood crib – model 1*** consists of 72 baguettes, the fuel load value is equal to 186.192 J.

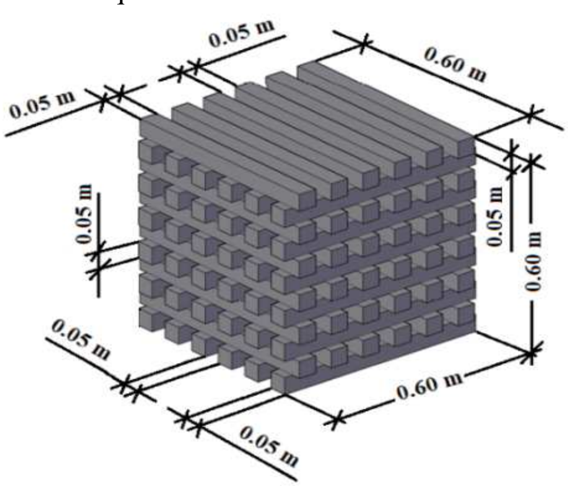

Fig. 4. Method of arrangement of the baguettes for the wood crib – model 1

According to fig. 5, the ***wood crib – model 2*** consists of 12 rows of baguettes, arranged 4 on each row, the distance between two adjacent baguettes, situated on the same layer, being 10 cm. The distance between the first, respectively the last, baguette of a row and the side faces of the wood crib, located in the immediate vicinity of the baguettes, is 5 cm.

Thus, taking into account that the ***wood crib –model 2*** consists of 48 baguettes, the fuel load value is equal to 124.128 J.

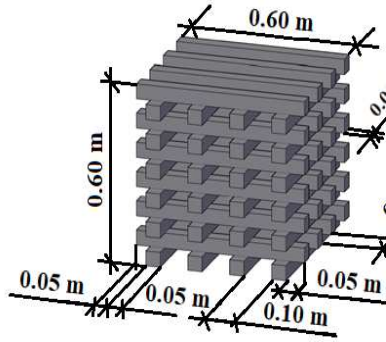

Fig. 5. Method of arrangement of the baguettes for the wood crib – model 2

According to fig. 6, the ***wood crib – model 3*** consists of 12 rows of baguettes, arranged 3 on each row, the distance between two adjacent baguettes, situated on the same layer, being 15 cm. The distance between the first, respectively the last, baguette of a row and the side faces of the wood crib, located in the immediate vicinity of the baguettes, is 7.5 cm.

Thus, taking into account that the ***wood crib – model 3*** consists of 36 baguettes, the fuel load value is equal to 93.096 J.

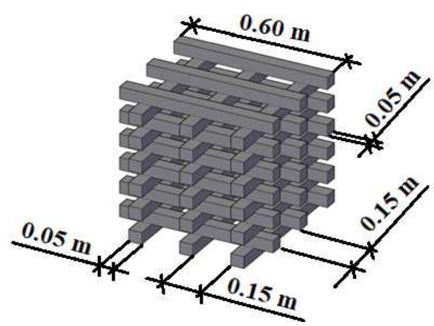

Fig. 6. Method of arrangement of the baguettes for the wood crib – model 2

There were performed 3 tests using ***wood crib - models 1, 2 and 3*** to analyze the temperature change recorded in the test area and the wood cribs mass loss.

3. MEASURING EQUIPMENT

A number of measuring equipments (as presented below) has been used to determine the temperature inside the test room as well as to determine the mass loss.

3.1. Measurement of temperature inside the test room

A number of 27 K-type thermocouples (T1-T27), placed on 3 layers (1.9 m, 1.6 m and 1.3 m from the floor), was used to measure the temperature inside the test room, forming 9 series of thermocouples, as shown in fig. 7, thus: series 1 - T1, T2 and T3; series 2 - T4, T5 and T6; series 3 - T7, T8 and T9; series 4 - T10, T11 and T12; series 5 - 13, T14 and T15; series 6 - T16, T17 and T18; series 7 - T19, T20 and T21; series 8 - T22, T23 and T24; series 9 - T25, T26 and T27.

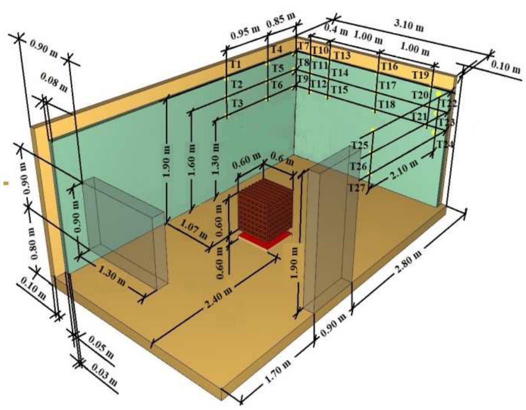

Fig. 7. Method of arrangement of the 27 thermocouples

K-type thermocouples (chromium-alumina), fitted with refractory steel sheath, diameter 6 mm, capable of readings from 0 to 1200 °C, were used to monitor temperatures on 3 layers in the fire space. The transmission of temperature changes is done by means of compensating cables that are connected to a laptop via a data acquisition module.

3.2. Measurement of mass loss

For the measurement of the wood crib mass loss, a system, shown in fig. 8, has been used consisting of: weighing platform (Argeo Dini, PB model with weighing management software), retaining tray of elements that become detached from the wood crib during combustion, fuel tray, where 3 L of ethanol is used to ignite the wood crib, respectively the wood crib.

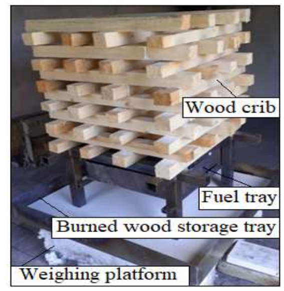

Fig. 8. Mass loss measurement system

4. Analysis of results

Fig. 9 shows the moment when the maximum temperature obtained in the test area is achieved in the case of ***wood crib - models 1, 2 and 3*** burning, which is recorded by thermocouple T2. This is due to the way the heat flow from the fire outbreak propagates, the heat flow being approximately perpendicular to the wall opposite the window open for ventilation.

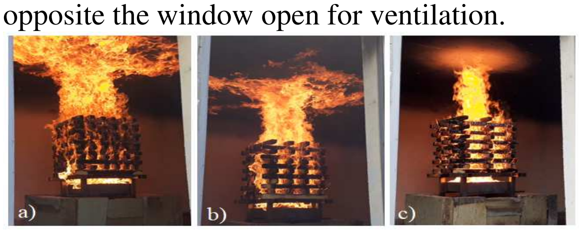

Fig. 9. Time of peak temperature in the test area in case of wood crib burning: a) model 1; b) model 2; c) model 3

The maximum temperature recorded by thermocouple T2 was 435,5 °C, about 484 s after ignition in the case of ***wood crib – model 1***, 443,2 °C, about 398 s after ignition in the case of ***wood crib – model 2***, 375 °C, about 525 s after ignition in the case of ***wood crib – model 3***. It is thus noted that the increase in the wood crib porosity (the increase in distances between two adjacent baguettes and, by extension, the cross-section area of the vertical openings of the wood crib) leads to an increase in the inflow of fresh air. Thus, a significant level of increase in the amount of air flowing through the wood crib openings, respectively a reduction in the burning surface of the fuel material (reduction of the total wood crib area by decreasing the number of baguettes), which is seen by comparison of the combustion of ***wood crib – model 1*** with ***wood crib – model 3***, reduces the maximum temperature recorded in the room and increases the time required to reach it.

The temperature value closest to that recorded by thermocouple T2 is the value obtained by thermocouple T26 located symmetrically in relation to T2 on the wall with the ventilation openings.

Table 1 shows the maximum recorded temperature values for each thermocouple series. Thus, for each of the 3 wood crib models, it is found that the maximum temperature values are recorded by the same thermocouples.

Table 1

Maximum series temperature values

Series	Thermocouple	Wood crib 1	Thermocouple	Wood crib 2	Thermocouple	Wood crib 3
Series 1	T2	435.5	T2	443.2	T2	375.7
Series 2	T5	351	T5	347.6	T5	302.2
Series 3	T8	284.9	T8	280.8	T8	249.6
Series 4	T11	330.5	T11	327.5	T11	284.2
Series 5	T14	340.6	T14	337	T14	290.8
Series 6	T17	343.4	T17	343.3	T17	253.7
Series 7	T20	304.3	T20	306.5	T20	267.1
Series 8	T23	288.9	T23	293	T23	258.2
Series 9	T26	398.6	T26	387.3	T26	354.3

The thermocouples which form ***Series 1*** recorded the highest values during the 3 tests, with a maximum value of 435 °C for thermocouple 2. Due to the relatively high surface value of the ventilation opening of 2.90 m^2 the stationary time of the accumulated hot smoke and gases in the ceiling was relatively small and they were quickly released outside. The temperature reading recorded by T1 thermocouple, located close to the ceiling, was lower than the temperature reading recorded by the T2 thermocouple, which is placed at a lower height than T1 from the floor. Through the ventilation opening, cold air entered in the lower area of the room, forming two different heat zones, the upper zone having a higher temperature value and the lower zone a lower value. Thermocouple T3, which is placed at the lowest height from the floor compared to the other two thermocouples, recorded the lowest temperature value.

The thermocouples which form ***Series 1*** and ***Series 9*** are closest to the center of the wood crib, approximately 1.5 m. This is also one of the reasons why the thermocouples which form ***Series 1*** and ***Series 9*** recorded the highest temperature values compared to the other series.

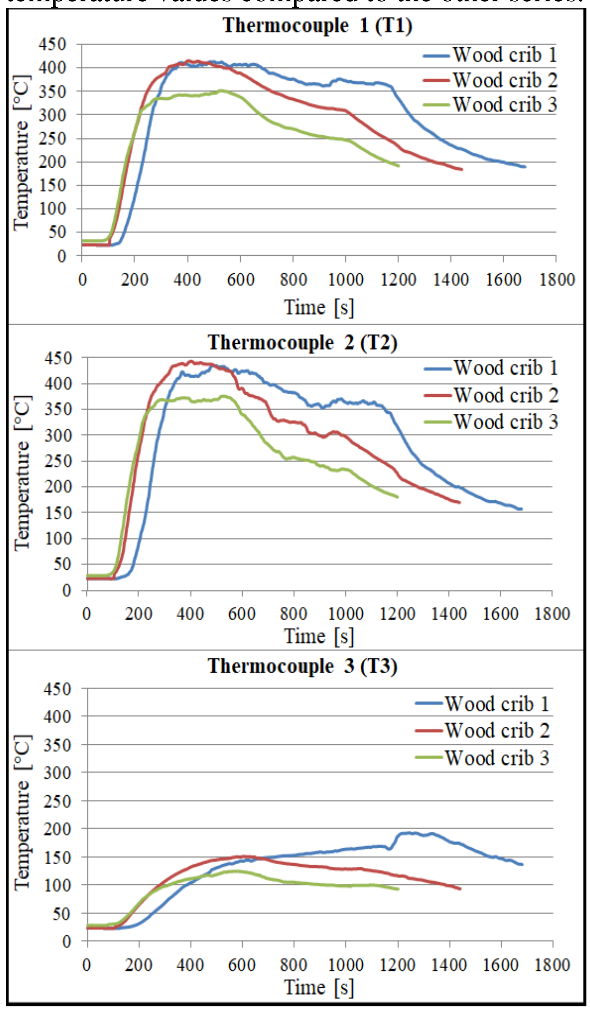

Fig. 10. Temperature variation recorded by thermocouples which form ***Series 1*** in case of 3 wood crib models combustion

Fig. 10 shows the comparison of the temperature values recorded by the T1-T3 thermocouples which form ***Series 1***.

The thermocouples which form ***Series 4*** and ***Series 7***, which are about 2.7 m from the center of the wood crib, respectively those of ***Series 5*** and ***Series 6***, which are about 2.4 m from the center of the wood crib, are placed on the wall opposite the window opening for ventilation, the heat flow being released perpendicular to this wall. This is why the recorded temperature values are relatively close, with thermocouples closer to the center of the wood crib, about 2.4 m compared with 2.7 m, recording higher values for ***wood crib – model 1*** and ***2***, characterized by a lower porosity value compared to ***wood crib – model 3***. As regards the ***wood crib – model 3***, the highest temperature values were recorded for thermocouples which form ***Series 4*** and ***Series 5***, thus noting that increasing the porosity level of a wood crib leads to the circulation of a higher air flow and thus to the development of higher temperature values.

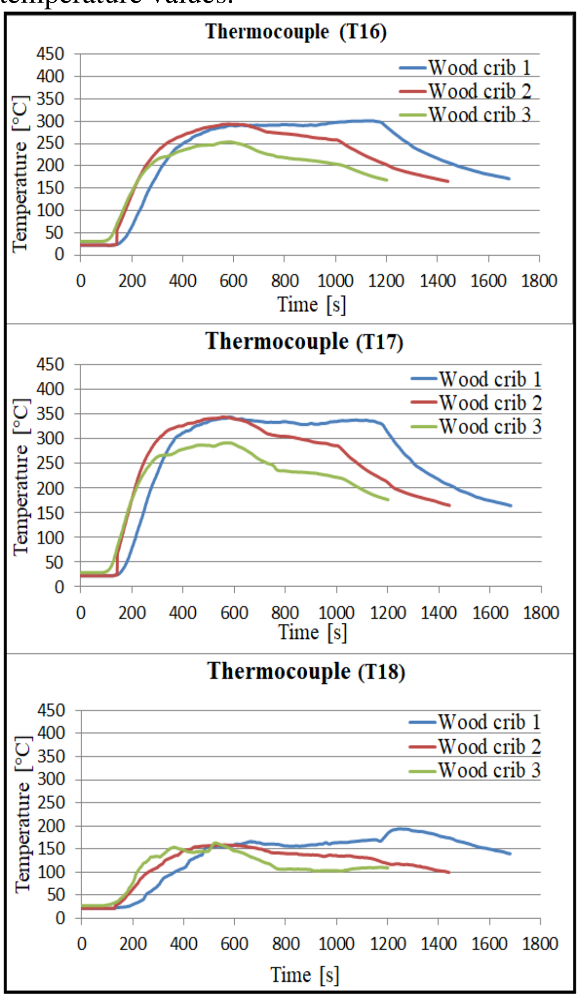

Fig. 11. Temperature variation recorded by thermocouples which form ***Series 6*** in case of 3 wood crib models combustion

Fig. 11 shows the comparison of the temperature values recorded by thermocouples which form ***Series 6***, namely thermocouple T16-T18, the highest temperature recorded in the wall opposite the window type ventilation opening being obtained by thermocouple T17.

The thermocouples which form ***Series 3***, located in a corner of the test room, at the boundary between the opposite wall and the one to the left of the window type ventilation opening, recorded the lowest temperature values. It is thus noted that the air circulation has a significant influence on the recorded temperature values, the smallest values being obtained in the corners of the rooms.

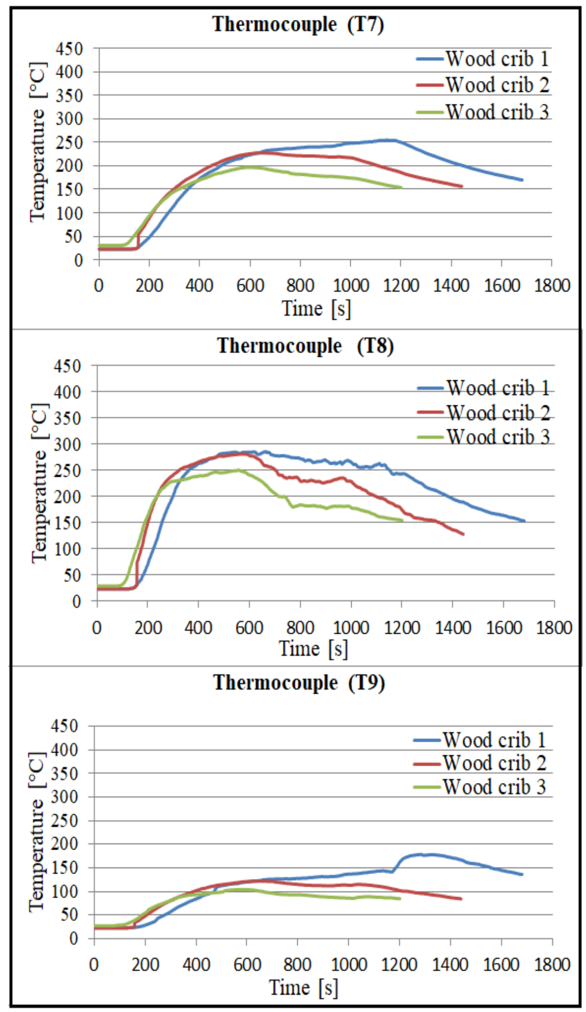

Fig. 12. Temperature variation recorded by thermocouples which form ***Series 3*** in case of 3 wood crib models combustion

Fig. 12 shows the comparison of the temperature values recorded by the T7-T9 thermocouples of the ***Series 3***. The highest temperature value has been recorded by the wood crib with the lowest porosity, and the lowest value is recorded for the wood crib with the highest porosity.

Fig. 13 shows the mass variation of ***wood crib - models 1, 2 and 3*** over time, the time interval 0-59 s does not take into account because of the significant fluctuation in the values obtained. Thus, ***wood crib - models 1, 2 and 3*** collapse within the range 1084 s to 1098 s (***model 1***), 936 s to 952 s (***model 2***) and 892 s to 909 s (***model 3***) after ethanol ignition, by suddenly decreasing the mass of the wood crib, plotted, from approximately 8.15 kg to approximately 3.95 kg (***model 1***), from approximately 4.85 kg to approximately 3.85 kg (***model 2***) and from approximately 5.15 kg to approximately 4.90 kg (***model 3***).

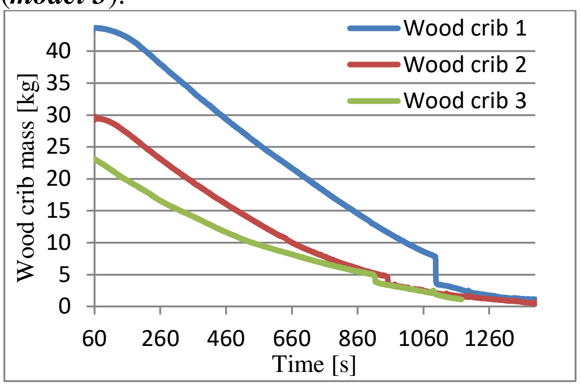

Fig. 13. Mass variation of wood crib - models 1, 2 and 3 in time

By calculating the mass loss rate from the time point of 60 s at the moment of wood cribs collapse, the values of 0,0347 kg/s are obtained for the ***wood crib - model 1***, 0,0278 kg/s for the ***wood crib - model 2***, 0,0216 kg/s for the ***wood crib - model 3***. The mass of the wood cribs also reaches a minimum value of 0.65 kg at 2057 s (***wood crib - model 1***), 0.55 kg at 1407 s (***wood crib - model 2***), 1.10 kg at 1176 s (***wood crib - model 3***).

The time variation of the HRR, calculated and normalized, is presented in fig. 14. The HRR parameter was obtained by the product of the mass loss of the ***wood crib – model 1, 2 and 3,*** calculated every 10 seconds and the value of 16.4 MJ/kg of the combustion heat of the pine wood.

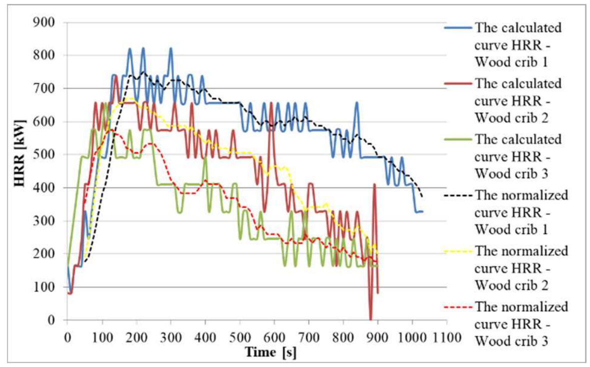

Fig. 14. HRR variation of wood crib - models 1, 2 and 3 in time

5. CONCLUSIONS

The purpose of this study was to analyze the influence of the porosity variation of a wood crib on the mass loss of the wood crib and on the change in temperature recorded in the test room. The porosity variation assumed to maintain the wood crib dimensions (in the form of a cube of 0.60 m side) and the baguette dimensions (length x width x height of 0.60 × 0.05 × 0.05 m) constant, respectively the change in the distances between the baguettes from the formation of the same layer (0.05 m — ***test 1***; 0.10 m — ***test 2***; 0.15 m — ***test 3***).

After 3 burning tests have been carried out in the test room, the following conclusions can be drawn:

a) The porosity of the wood crib significantly influences the burning behavior. In the case of a wood crib characterized by minimum porosity, the inflow of fresh air through the vertical openings of the wood crib is smaller, resulting in a high level of incomplete combustion. High porosity wood cribs are characterized by a greater amount of air flowing through the wood crib openings, which increases the intensity of combustion and heat released. Thus, as the porosity of the wood crib increases, for the same dimensions (0.60 x 0.60 x 0.60 m), the mass of the wood crib decreases. This leads to a decrease in the value of the maximum temperatures recorded inside the fire compartment.

b) The highest temperatures were not recorded by thermocouples located on the walls, in close proximity to the ceiling, but by thermocouples located about 0.3 m below it, meaning at the bottom of the smoke layer formed in the test room. Due to the relatively large ventilation openings surface of 2.90 m^2, the stationary time of smoke and hot gases in the immediate vicinity of the ceiling is relatively small and they are evacuated outside. Thus, the maximum temperatures were not recorded by the thermocouple layer in the immediate vicinity of the ceiling (1.90 m above the floor, on the walls), but by the thermocouple layer located 0.30 m below. As the fire compartments are characterized by a high temperature zone and a lower temperature zone, the thermocouple layer located at a height of 1.30 m has the lowest values.

c) The wood cribs mass loss rate is controlled by the porosity and the mass value. Thus, the larger the wood crib weight and the smaller the porosity (***wood crib - model 1*** has the maximum mass and minimum porosity, and ***wood crib - model 3*** has the minimum mass and maximum porosity), the faster the mass loss rate increases.

d) The value of the free burning time of the wood cribs increases with the growth in the mass of the wood cribs, and thus with the increase in the value of the fuel material surface exposed to fire.

e) Both the mass value at the time of the wood crib collapse (8.15 kg for ***wood crib - model 1***) and the sudden loss in mass (4.20 kg for ***wood crib - model 1***) recorded at the time of the wood crib collapse are higher for the wood crib with the minimum porosity.

f) Once the maximum mass loss is reached, higher porosity wood cribs show a steeper curve compared to smaller porosity wood cribs. This is due to the higher inflow of air, which results in faster combustion.

g) Analyzing fig. 14 it is found that the HRR parameter varies directly proportional to the mass of the burning wood crib and inversely proportional to the degree of the wood crib porosity.

Acknowledgments:

This work was supported by a grant of the Romanian Ministry of Research and Innovation, CCCDI-UEFISCDI, project number PN-III-P1-1. 2-PCCDI-2017-0350/02.03.2018 (Graphene4Life), within PNCDI III.

REFERENCES

[1] Zhang, S., Ni, X., Zhao, M., Zhang, R., & Zhang, H. (2015). Experimental study on the characteristics of wood crib fire in a confined space with different ventilation conditions. Journal of Thermal Analysis and Calorimetry, 120(2), 1383-1391.

[2] Zhang, S., Ni, X., Zhao, M., Feng, J., & Zhang, R. (2015). Numerical simulation of wood crib fire behavior in a confined space using cone calorimeter data. Journal of Thermal Analysis and Calorimetry, 119(3), 2291-2303.

[3] Dhurandher, B. K., Kumar, R., Dhiman, A. K., & Gupta, A. (2017). Investigation of thermal equilibrium in a compartment involving crib fire. Journal of Thermal Analysis and Calorimetry, 129(3), 1787-1797.

[4] Cioca L. I.; Moraru R. I.; Explosion and/or fire risk assessment methodology: a common approach, structured for underground coalmine environments so archives of mining sciences, Archives of Mining Sciences, Volume 57, Issue 1, pp. 53-60, 2012, IF 0,319.

[5] Beyreis, J. R., Monsen, H. W., & Abbasi, A. F. (1971). Properties of wood crib flames. Fire Technology, 7(2), 145-155.

[6] Anderson, J., Sjöström, J., Temple, A., Charlier, M., Dai, X., Welch, S., & Rush, D. (2021). FDS simulations and modelling efforts of travelling fires in a large elongated compartment. Fire and Materials, 45(6), 699-707.

[7] Heskestad, G. (2006). Heat of combustion in spreading wood crib fires with application to ceiling jets. Fire safety journal, 41(5), 343-348.

[8] Gupta, V., Torero, J. L., & Hidalgo, J. P. (2021). Burning dynamics and in-depth flame spread of wood cribs in large compartment fires. Combustion and Flame, 228, 42-56.

[9] P.H. Thomas, Some aspects of the growth and spread of fire in the open, Forestry 40 (1967) 139–164 .

[10] Bjørge, J. S., Gunnarshaug, A., Log, T., & Metallinou, M. M. (2018). Study of industrial grade thermal insulation as passive fire protection up to 1200° c. Safety, 4(3), 41.

[11] Croce, P. A., & Xin, Y. (2005). Scale modeling of quasi-steady wood crib fires in enclosures. Fire Safety Journal, 40(3), 245-266.

[12] Li, Y. Z., & Ingason, H. (2017). Scaling of wood pallet fires. Fire safety journal, 88, 96-103.

[13] Keshavarz, G., Khan, F., & Hawboldt, K. (2012). Modeling of pool fires in cold regions. Fire safety journal, 48, 1-10.

[14] Suzuki, M., Kushida, H., Dobashi, R., & Hirano, T. (2000). Effects of humidity and temperature on downward flame spread over filter paper. Fire Safety Science, 6, 661-669.

[15] Rush, D., Dai, X., & Lange, D. (2021). Tisova Fire Test–fire behaviours and lessons learnt. Fire Safety Journal, 121, 103261.

[16] Dhurandher, B. K., Kumar, R., Dhiman, A. K., & Gupta, A. (2019). An Impact of Sudden Ventilation in a Compartment Involving Crib Fire. Iranian Journal of Science and Technology, Transactions of Mechanical Engineering, 1-12.
[17] Diab, M. T., Haelssig, J. B., & Pegg, M. J. (2020). The behaviour of wood crib fires under free burning and fire whirl conditions. Fire safety journal, 112, 102941.
[18] Xu, Q., Griffin, G. J., Jiang, Y., Bicknell, A. D., Bradbury, G. P., & White, N. (2008). Calibration burning of wood crib under ISO9705 hood. Journal of thermal analysis and calorimetry, 91(2), 355-358.
[19] Thomas, P. H., Simms, D. L., & Wraight, H. G. (1964). Fire spread in wooden cribs. Fire Safety Science, 537, 1-1.
[20] Bintu Grema Mustafa, Garba Magaji & Babagana Gutti (2013). Air starved compartment fire analysis on different wood crib sizes. Global Journal of engineering, design & technology, ISSN 2319-7293.
[21] Smith, P. G., & Thomas, P. H. (1970). The rate of burning of wood cribs. Fire Technology, 6(1), 29-38.
[22] Rios, J., Welker, J. R., & Sliepcevich, C. M. (1967). Interaction effects of wind-blown flames from wood crib fires. Fire Technology, 3(2), 129-136.
[23] Matvienko, O., Kasymov, D., Loboda, E., Lutsenko, A., & Daneyko, O. (2022). Modeling of Wood Surface Ignition by Wildland Firebrands. Fire, 5(2), 38.
[24] McAllister, S., & Finney, M. (2016). The effect of wind on burning rate of wood cribs. Fire technology, 52(4), 1035-1050.
[25] McAllister, S., & Finney, M. (2016). Burning rates of wood cribs with implications for wildland fires. Fire technology, 52(6), 1755-1777.
[26] Thomas, P. H., Simms, D. L., & Wraight, H. G. (1965). Fire spread in wooden cribs, part II Heat transfer experiments in still air. Fire Safety Science, 599, 1-1.
[27] Weng, W., Kamikawa, D., & Hasemi, Y. (2015). Experimental study on merged flame characteristics from multifire sources with wood cribs. Proceedings of the Combustion Institute, 35(3), 2597-2606.
[28] Trevits, M. A., Smith, A. C., Urosek, J. E., & Valoski, M. P. (2002). Evaluation of deep-seated crib block fire tests.
[29] Scheffey, J. L., & Williams, F. W. (1991). The extinguishment of fires using low flow water hose streams—part I. Fire technology, 27(2), 128-144.
[30] Rappsilber, T., Below, P., & Krüger, S. (2019). Wood crib fire tests to evaluate the influence of extinguishing media and jet type on extinguishing performance at close range. Fire Safety Journal, 106, 136-145.
[31] Noaki, M., Delichatsios, M. A., Yamaguchi, J. I., & Ohmiya, Y. (2018). Heat release rate of wooden cribs with water application for fire suppression. Fire Safety Journal, 95, 170-179.
[32] Petrache M. A., Influența dimensiunilor și formei stivelor de lemn asupra pierderii de masă si temperaturii în spații închise în aceleași condiții de ventilare, Lucrare de diplomă, 2021.

Influența formei stivelor de lemn asupra pierderii de masă și a temperaturii în spații închise

Rezumat: Forma stivelor din lemn are o influență importantă atât asupra pierderii de masă a stivelor, cât și asupra valorilor temperaturii înregistrate în interiorul compartimentului de incendiu. Astfel, în cazul stivei cu gradul cel mai ridicat al porozității, atât pierderea totală de masă cât și pierderea bruscă de masă măsurată în momentul prăbușirii stivei sunt maxime. De asemenea, valoarea medie a temperaturii maxime înregistrate în compartimentul de incendiu precum și viteza de ardere cresc odată cu creșterea porozității stivei.

Ion ANGHEL, Ph.D, Eng., Assistant professor, Police Academy, Fire Officers Faculty, Romania, ion_anghel2003@yahoo.com

Alexandru-Florin CHIOJDOIU, PhD. Stud., Eng., Fire department commander, The Inspectorate for Emergency Situations „Dealul Spirii" Bucharest-Ilfov, Romania, alex.floryn@yahoo.com

Mădălin Adrian PETRACHE, PhD. Stud., Eng., The Inspectorate for Emergency Situations „General Magheru" of the County Vâlcea, 240255 Râmnicu Vâlcea, Romania; madutzu.ady@gmail.com

Sebastian VRABIE, PhD. Stud., Eng., The Inspectorate for Emergency Situations „Anghel Saligny" of the County Vrancea, 620087 Focșani, Romania; sebivrabie98@gmail.com