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EVALUATION OF THE FINS ACTING IN THE CHARCOAL COOLING PROCESS IN V&M FLORESTAL CARBONIZATION KILNS

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Abstract: *The present work presents a comparative experimental study of the cooling of the charcoal in the V&M Florestal industrial kilns FR190 in two different situations: the current process with water pulverization and the process proposed without water pulverization, but with external fins. The objective of the study is the increase of the productivity of the kilns FR190 with the reduction of the cooling time. Besides, the elimination of the water consumption reduces the environmental impact of the process with no formation of liquid polluted effluents in the kilns. Was tried to accomplish try them in two kilns with the same dimensions and constructive characteristics, one of them with external fins, with the same wood loads weight and nature. The carbonization processes were started simultaneously and they were controlled by the same carbonization technicians. A date acquisition system registered the thermocouples temperatures installed inside the kilns. The fins were shown effective and the cooling of the charcoal that is about 6 days with the water pulverization passed for 5 days without pulverization. The studies and experiments continue in the sense of improving the yield of the kilns with fins with the modification of the configuration and/or the increase of the number of fins. The spray of small amounts of the water in the outside surface of the fins will be tried also.*

Keywords: *Carbonization Process, Rectangular Kilns, Charcoal, Cooling.*

1. INTRODUÇÃO

The carbonization process is the process of transformation of the wood in charcoal, through his/her exhibition the superior temperature to 200ºC, in atmospheres with controlled dosage of oxygen (CAMPOS, 2000). the rude wood is put into the kiln and part of her is burned for the ignition of the process. The ignition liberates the necessary energy for the carbonization of the remaining of the put into the kiln firewood. After the end of the carbonization process, he/she has beginning the cooling of the charcoal that should happen with the prohibited kiln, avoiding that the charcoal, at high temperatures (450°C) of ignition when in contact with the oxygen. The whole process, from the load of the wood to the unloading of the charcoal, takes around 12 days. Of these, six days it is approximate time of the cooling process with the use water.

Now, V&M Florestal (VMFL) it possesses, among other, 209 kilns FR190, that will be object of this work. In those kilns VMFL produces all the charcoal that is used in the high-kilns of the plant Barreiro, in Belo Horizonte, Minas Gerais. The optimization of the carbonization process is of extreme importance for reduction of the cost and increase of the productivity of the charcoal given the Usina Barreiro, making possible VMB to produce more competitive tubes of steel in the world market.

The standard procedure for the cooling of the rectangular kilns in VMFL consumes 6.000 liters of water between beginning and the fourth hour of the cooling. Besides the environmental impacts, the use of the water in the cooling process generates several other problems as decrease of the mechanical resistance of the charcoal and overload in the walls.

The present work search to evaluate cooling conditions being eliminated the use of water in the process with the use of a prototype of dressing room of heat installed in an kiln FR190. He/she hopes to reduce of the time of cooling, to generate a smaller environmental impact due to the not use of natural resources and reduction in the formation of liquid outlets in the kilns and to propose improvements for the prototype.

2. METHODOLOGY

For the experiment the following materials were used:
" Unit of acquisition of date;
" 16 Thermocouples type k;
" 2 rectangular industrial kilns FR190;
" 6 dressing room of heat;

" 2 Tar recover;
" System of water inject of water.

The adopted procedure was followed in two kilns with similar geometric characteristics (length, positions of the entrances and exit of gases). The kilns were FR49 equipped with the dressing room of heat and the second kiln was FR52. The two kilns are part of the group of kilns of research of V&M Florestal in Itapoã Farm. The difference among the kilns is that the kiln FR52 possesses circulation of the lateral gases and FR49 central circulation.

Each kiln was operated with his tar recovery device. The tar recovery of the kiln FR52 had the frequency investor installed and the tar recovery of the kiln FR49 no.

A same carbonizador operated the two kilns of the beginning at the end of the process. They were following the same operational procedures for whole the experiment, from the load at the end of the cooling. It was made the load with the same wood (species, dates from cut and mass, medium diameter etc) in the two kilns. The ignitions were in the same instant.

The attendance of the processes was made with the registration, with the smallest interval of time, of the medium temperatures of the kiln, in the dressing room of heat and in the beds (wood and charcoal). The kilns were scored with thermocouples put in the positions conforms the Figure 1. The module of acquisition of date was used for the registration of the temperatures. The acquisition interval was of 10 seconds.

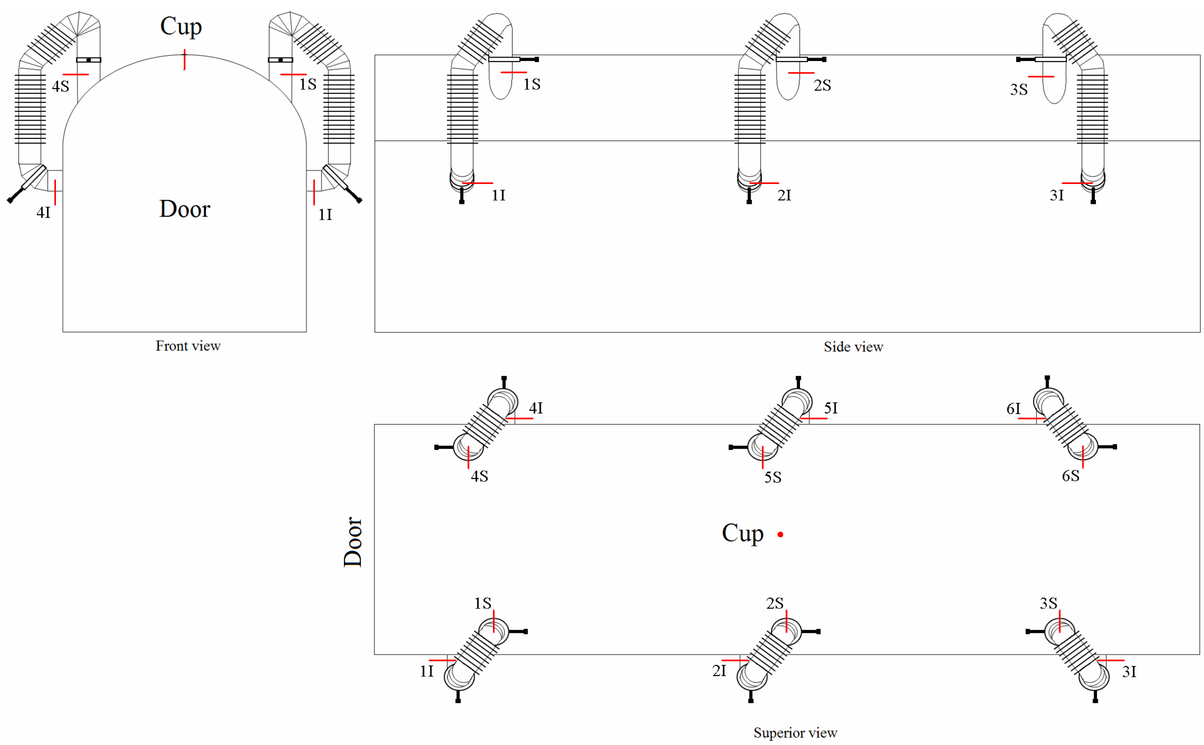

Figure 1: Position of thermocouples installed.

It was looked for to maintain the representative medium temperatures of the kilns (Thermocouple of the Cup) the closest possible until the beginning of the cooling. It is endly, all were notified of the events (opening of valves, rain, stop of the tar recovery etc).

The propositions of improvements of the prototypes are in operational simplifications, reductions of costs and environmental impacts, increase in thermal efficiency etc. The increase thermal efficiency of the prototypes is gotten through the analysis of materials and for the sizing of their fins.

The cooling of the system consists of the cooling bed of charcoal, of the structure of the kiln and of the gases in his interior will be same to the heat liberated for the atmosphere by the prototypes. Considering that the walls of the kiln are adiabatic the swinging of energy of the system will be applied then for the calculation of the fins.

3. RESULTS

The results presented to proceed were obtained through the application of the method presented for evaluation of the dressing room of heat installed in the kiln FR49 of the research of VMFL. In the Table 1 the summary of the date is presented obtained through the execution of the procedures described in the Operational Pattern Researches VMFL2007.

Table 1: Data of furnaces.

Kiln FR49			
Wood			
Mass dry [kg]	48.350	Date of Ignition	26/01/07
Volume [st]	150	Length [m]	3,5
Diameter avarage [cm]	14	Specie	Urophylla
Porosity batch [%]	50	Moisture d.b. [%]	61
Tiço			
Mass dry [kg]	7980	Volume [m³]	19
Charcoal			
Mass dry [kg]	10560	Moisture d.b. [%]	6,4
Volume [m³]	38	Fixed carbon [%]	77
General			
Yields	21,8	Date of Opened	07/02/07
Kiln FR52			
Wood			
Mass dry [kg]	49.336	Date of Ignition	26/01/07
Volume [st]	166	Length [m]	3,5
Diameter avarage [cm]	13	Specie	Urophylla
Porosity batch [%]	49	Moisture d.b. [%]	53
Tiço			
Mass dry [kg]	12660	Volume [m³]	27,2
Charcoal			
Mass dry [kg]	9643	Moisture d.b. [%]	**4,6**
Volume [m³]	32	Fixed carbon [%]	84
General			
Yields	19,5	Date of Opened	07/02/07

The Figure 2 shows the curve of temperature versus time of those furnaces.

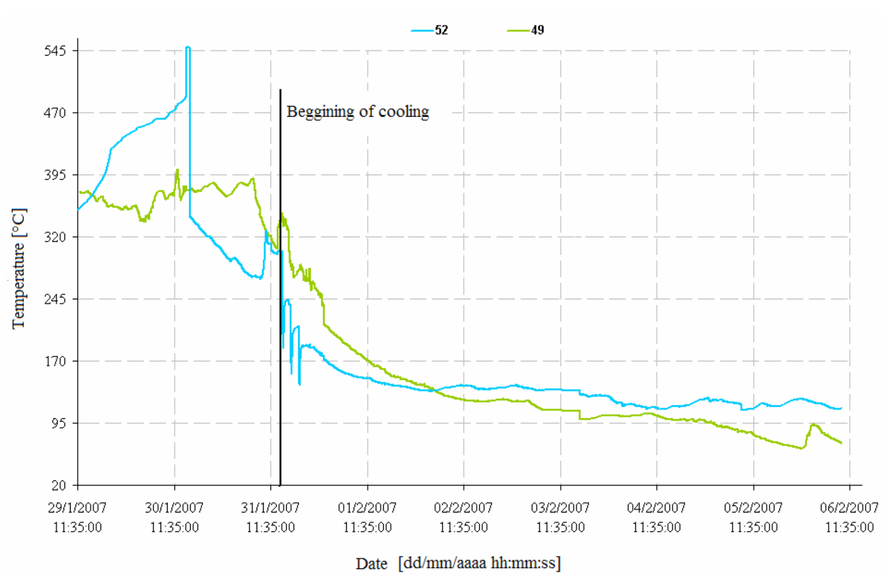

Figure 2: Register of the readings of temperature of the day 29/01/07 11:35 to day 06/02/07 10:00.

Calls the attention for the maximum temperature in the kiln FR49, that didn't cross 400°C, that it can be visualized in the graph of the Figure 2. The sensibility of the answer the use of the thermocouple is visualized in the cup associated to the short interval among the readings, turning easier to identify the effectiveness of the actions. It was difficult to maintain the same temperature in the two kilns, as it can be visualized in the behavior of the graphs. It is believed that was due to the lack of a frequency investor in the apparel of the kiln FR49 and to the position of the chimney of the kiln FR52.

In the Figure 3 it presents the curves of the cup temperatures and their respective tendency lines during the cooling phase.

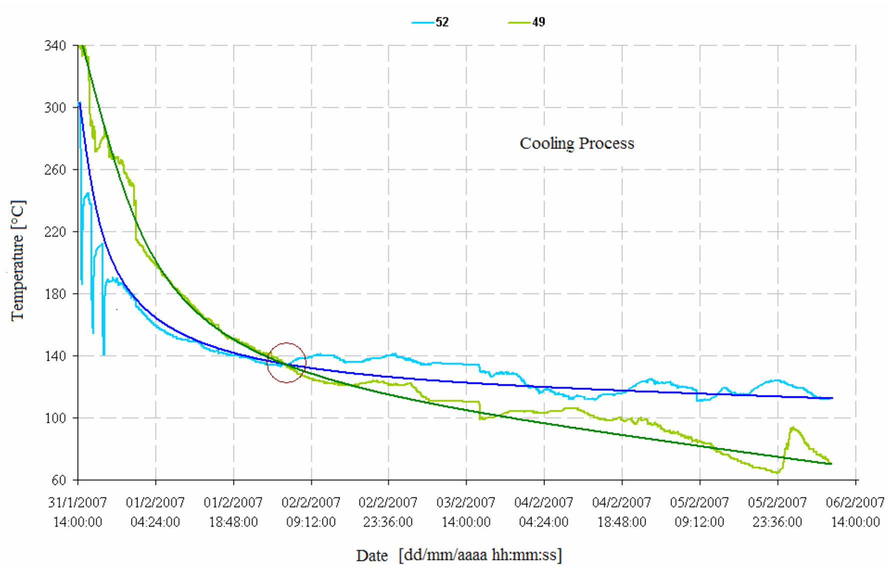

Figure 3: Cooling of kilns FR49 e FR52.

Table 2: Mains instants of cooling.

Instant	Date e hora	FR49	FR52
Begin of Water inject	31/01/07 14:32	360ºC	300ºC
End of Water inject	31/01/07 19:32	292ºC	188ºC
Same Temperature	02/02/07 04:12	134ºC	134ºC
Opened of kilns	06/02/07 14:42	72ºC	112ºC

The main instants of the cooling phase are shown in the Table 2. it is Verified that the kilns didn't begin the cooling with the same temperature. The medium taxes of cooling of the kilns ºC/h during the main moments since the beginning of the cooling (31/01/07 14h32min) they are shown in the Table 3, to proceed.

Table 3: Tax of cooling of the kilns at the main moments of the cooling.

Moment	FR49	FR52
Water inject	-13,6 ºC/h	-22,4 ºC/h
Same temperature	-6,0 ºC/h	-4,4 ºC/h
Global	***-2,0 ºC/h***	***-1,3 ºC/h***

The goal the being reached is the increase of these tax, in other words, for 75% of carbon I fasten the end temperature of carbonization, theoretically, it should be 450°C. This way to reach 50°C at the end of the fifth day of cooling the tax of global cooling should be in about 3,5°C/h.

It is possible to notice the effects of the water inject of the kiln clearly FR52. It is verified that the temperature in the cup lowers about 50°C in the first water inject and 35°C on Monday and in the third.

After the water inject phase the kiln FR52 starts to catch a cold due to the loss of heat in his/her structure. In this aspect the kiln FR49 is more efficient due to the dressing room of Heat. Even with the difference of initial temperature of the cooling in 50°C, the kiln FR49 gets to equal his/her temperature the one of the kiln FR52 before completing 2 days of cooling. However the two systems lose efficiency as the temperature approaches the room temperature, their behaviors can be seen in the line of tendency of the graphs of the Figure 3.

The Figure 4 display the dressing room of heat 5 behavior. This behavior was typical of all of the dressing room of heat.

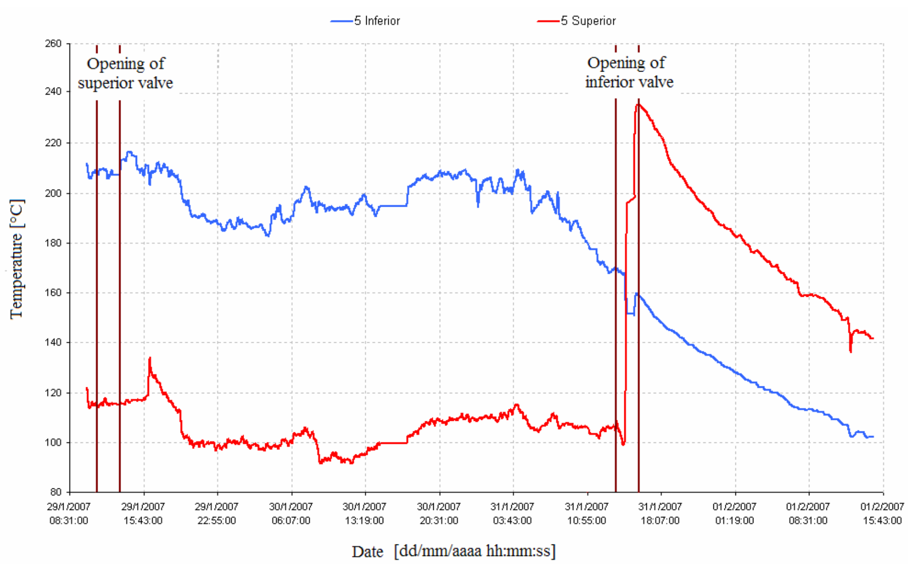

Figure 4: Behavior heat transfer 5 during the time.

It is veriffied that the levels of the temperatures in the dressing room superior and inferior part are high, average of 160°C, during whole the process. This generates a loss of heat during whole the carbonization process. This is the main fact that made the temperature of the cup not to cross 400°C as it was said previously.

It was verified that the temperature in the inferior part of the dressing room of heat was always higher, average of 200°C. This happened while the valves were closed, because there was not mass flow. This way the gas kept inside the dressing room was heated up forming a gradient thermal fence 200°C in the inferior part to 110°C in the superior.

In the moment of the dressing room opening, with the liberation of the flow of internal gas, this thermal gradient inverts their landings, being hotter in the superior and less part in the inferior. The inversion of the thermal gradient in the moment of the opening of the dressing room of heat repeated in all of the dressing room of heat. This criterion was used for determination of the efficiency of close of the valves. First, they were open the superior valves. The thermal behavior was evaluated in the two thermocouples of the dressing room on these moments. Any alterations were not verified in the temperatures in the part inferior or superior. This indicates that there was not flow inside of the dressing room with just one of the valves opened.

This behavior shows that the superior valves beyond be not necessary to the vedações, they are of difficult operation, because the operator has to arise in the cup of the hot kiln to open them. However, he/she is still due to evaluate the maintenance aspects of the dressing room to the you operate them with the opened superior valve, because it is believed in a larger incrustation of tar in this condition.

The Figure 6 is shown the operational of opening and closing of the valves of the dressing room of heat.

Figure 6: Operational of opened of valves of the heat exchangers device.

It was tried to accelerate the process of cooling of the kiln FR49 playing water in the external part of the dressing room of heat. 600 litters of water were played, however the system was shown very inefficient. The results are visualized in the Figure 7.

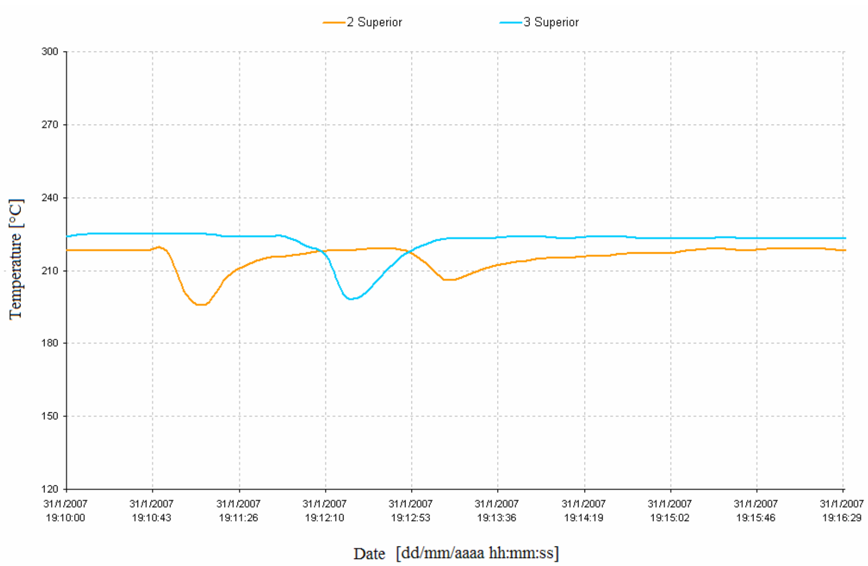

Figure 7 - Effect of water inject of 600 litters of water on heat exchangers 2 e 3.

The only temperature variation that was verified during this whole procedure was in the dressing room of heat 2 and 3 superior thermocouples. However this effect just lasted about 2 minutes and it didn't get to affect the temperature global measure in the cup.

4. CONCLUSION

The tax of cooling of the kiln with the dressing room of heat was superior, as it was of waiting, however the system still needs improvements, as the study of water inject of water.

The taxes had picks of 22,4 and 13,6 °C/h in the kiln with the use of water and without respectively, however it was not possible to maintain this landing besides the first 5 hours of the cooling. At the end, the global taxes were in 1,3 and 2,0 °C/h to and without water respectively.

The temperature of maximum cup reached in the kiln with dressing room was limited in 400°C, what can commit the goals of fixed carbon. The reason is the dressing room of heat, that same closed still lose heat for the atmosphere.

The valves installed in the superior part of the dressing room of heat are not justified operational and technically. Endly, the system for inject water in the external part of the dressing room of heat was shown inefficient.

The next steps are:

1. to continue looking for to reach a tax of larger cooling (3,5°C/h) in the kilns with the dressing room of heat with the optimization of the configuretion and/or the increase of the number of fins.
2. to accomplish more comparative tests, for the determination of the global taxes of cooling for the processes:
   a. without water in the traditional kilns without dressing room
   b. new water inject procedures;
   c. with water in the kiln with dressing room.

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