STUDY OF THE CONTROL OF THE CARBONIZATION PROCESS THROUGH THE GASES SUCTION VARIATION IN V&M FLORESTAL RECTANGULAR KILNS FR190

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Abstract: *The present research is a summary of the activities developed in the V&M Florestal on 2006 on a project in partnership with the UFMG. In this context was studied the influence of the gases suction variation in the carbonization process in V&M Florestal industrial kilns FR190. This work's objective is to get standard and improve the V&M Florestal carbonization process and increase the kilns productivity, yields and rise the homogeneity of the charcoal produced. It was possible to evaluate the influence of the variation of the suction of the deriving gases of the process, in comparison with the current system. At a first moment the furnaces without variation of the gases suction had been evaluated and later the furnaces was controlled through the suction of the gases for comparison and analysis of the results had been evaluated. An increase of the yields for the controlled furnaces through the suction of the gases was observed, however did not have significant improvement in the quality of the produced charcoal nor of the productivity of the furnaces.*

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

1. INTRODUCTION

1.1. Process of carbonization

When wood is submitted to heat at a very high temperature it suffers many transformations that release all of its components (hemicelluloses, cellulose and lignin), in gas form (carbon monoxide, carbon dioxide, hydrogen etc), in liquid form (water, tars, acetic acid, metilic alcohol etc) and solid residue, vegetal charcoal.

The pyrolysis is the process where wood is heated in a lethargic environment or in a closed environment containing an air exit. Carbonization is the transformation of wood in charcoal through heat action with controlled quantities of oxygen (air). In conventional processes of carbonization, where there is a controlled air presence, the wood is always carbonized, thus pyrolysis has taken place. The heat that comes from this burn is responsible for heating and transforming of the rest of the wood into charcoal [GOMES and OLIVEIRA, 1980].

In the practice of carbonization, one tries to maintain a temperature between 380ºC and 500ºC. Due to the degradation of the wood's basic components occurring in different parts of this temperature interval, it is necessary to guarantee that the high temperatures are reached in the carbonization process to guarantee that the wood's transformation is the most complete [OLIVEIRA et al, 1984]. However, to reach the desired temperatures, parts of in furnace wood is burned with contact to a flame and large atmospheric air quantities (oxygen). It's from the emitted energy in this burn that it becomes necessary to heat the beginning of the carbonization of the rest of the wood [GOMES and OLIVEIRA, 1980]. This is the principle of function of the furnaces that work with self heat.

The air quantities introduced into carbonization furnaces must be measured well, in a way to obtain charcoal with good characteristics without, however, causing the wood to over burn. Thus, in the vegetal charcoal production's conventional processes, as much income as the physical and chemical qualities of the product will depend not only of the wood characteristics, but also the characteristics of the equipment and the operator ability.

1.2. Physical model

The rectangular kilns standout due to their configuration and size (volumetric capacity of 190m³). They were created in this way to permit the entrance of heavy machines to do the shipment of the firewood and the discharge of the charcoal.

However, the rectangular configuration does not favor the stream of gases. Large zones arrive at the end of the process without reaching carbonization, generating the tiço (pre carbonized wood). To control this process, they have installed in the kilns four chambers, and to diminish the output of charcoal they were arranged symmetrically around the kiln, as to permit the introduction of air under the bed of wood. The Figure 1 illustrates schematically the configuration of the FR190.

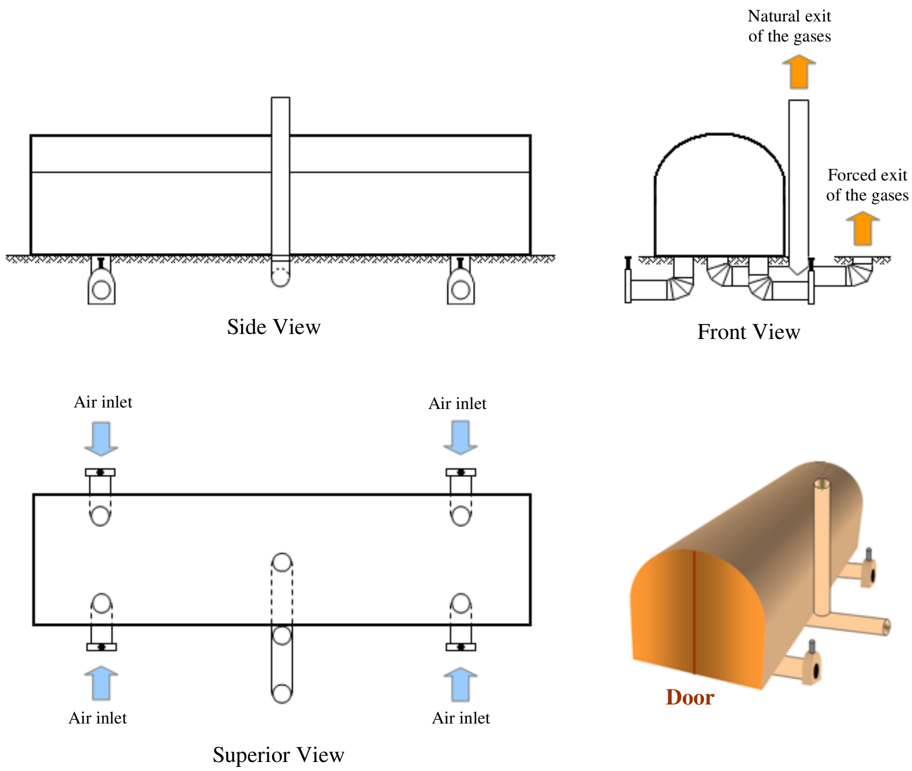

Figure 1: Schematical drawing of the kilns FR190.

The circulation of gases is done by a pipe that is located on the floor in the center of the kiln. That pipe is coupled to a chimney and a tar recovery device enabling the natural circulation of forced gases arising from the carbonization. In the four kilns disposed for that work, the air entrance chambers were equipped with graduated valves that are utilized entirely open or entirely closed.

Therefore, the tools of available to control the carbonizator are the graduated valves and the tar recovery device. Beyond the tools of control, the carbonizator has at its disposal two tools accompanying the furnaces. One of them is a graphic representation of the temperature versus time, where also the medium temperature is inside a predetermined limit at the moment of the temperature reading. The other one is a profile of the charcoal's temperatures, measured by an infrared sensor (pyrometer) in 28 points spread around the perimeter of the kiln, and permits to know the location and the value of the temperatures at a given instant.

2. OBJECTIVES

Study and compare the process of carbonization in kilns FR190 of the V&M Florestal, through the control of the stream of air supplied to the system made of two forms:

- Through the control of the entrance of air into the four chambers symmetrically arranged around the kilns, without suction variation of gases;
- Through the variation of the suction of the hot gases provided by the tar recovery device equipped with an inverse of frequency.

3. DEVELOPMENT

3.1. Instrumentation installed in the kilns

The instrumentation of the kilns was constituted by:

- A tar recovery device that causes the gases forced retreat. It was installed an inverse of frequency in the motor of suction, enabling the variation of the suction of the gases;
- Pyrometer, that is utilized for the measurement of temperature in the pipes of instrumentation installed in the walls of the kilns.

3.2. Methodology for accompaniment of the furnaces

The kilns FR190 count on a temperature monitoring program for accompaniment of the furnaces. It consists of the measurement of the kilns internal temperature, utilizing a pyrometer. The distribution of the pipes in the walls, where the measurements are made, they try to monitor the main critical points of the kiln, including the air entrance and exit at the gases locals, beyond the monitoring of the region near the door and at the bottom.

In the phase of carbonization, one of the main objectives of the monitoring of temperature is to avoid the combustion of the already formed charcoal, caused by lack of control in the entrances of air (threesomes in the walls and vault, leaks in the door etc). Another important correcting action is going to detect cold points, and the carbonizator acting by means of the entrances of air or by the variation of the rotation of the motor of the tar recovery, increase the temperature of the kilns in those regions, maintaining the process inside a streak of correct temperature.

In a work carried out in the sector of research of the V&M Florestal, it was determined by a curve of temperature versus time. That the temperature considered is collected by the system of monitoring saw infrared, described above. It collects the temperatures along one of the kilns' perimeter, finds an average and considers-itself that value as representative of the medium temperature of the process in the moment. Those values are plotted in a curve of temperature in function of the time, and the course of the furnace is compared with a standard curve.

Therefore, the carbonizator counted on two tools of accompaniment. And it indicates the behavior located of the course of the process and to another one indicates the global behavior. The Figure 2 illustrates the temperature standard curve versus continued time in the furnaces.

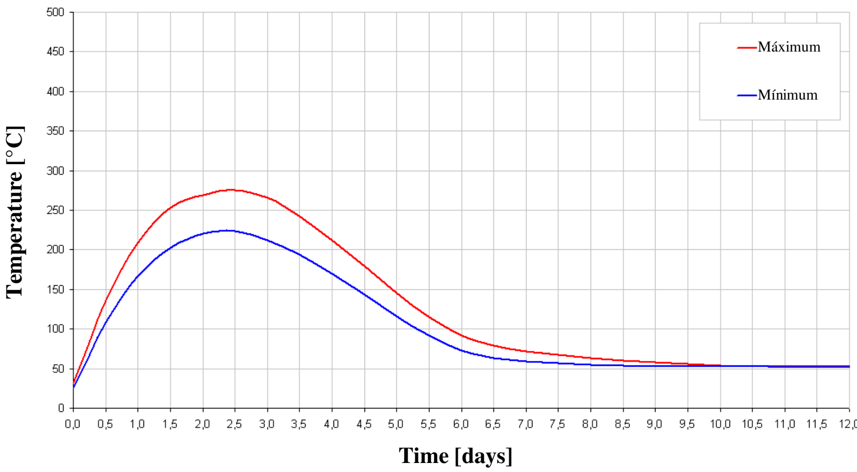

Figure 2: Temperature standard curve versus continued time in the furnaces.

It can be observed that the highest medium temperature does not surpass 275°C. It is able to look incoherent in an exothermic process such as carbonization; however is necessary to remember that it is a matter of a medium one at several points of measurement. Some points can be above that value that allied with others that are down, resulting in the temperature indicated by the curve.

3.3. Methodology for collection of the datas

For evaluation of the furnaces some classification criteria was utilized for the parameters utilized. That classification was permitted to determine itself the value of the data obtained, and whether the charcoal was considered great, good or bad. For it to raise those indices it was necessary to know the desirable qualities for the charcoal utilized like term reducer in steel-industry factories. Beyond the desirable qualities, it was necessary to determine the great indices for each parameter, separating them in worthy streaks and classifying them.

The Table 1 presents the classification of the parameters considered, separating them by worthy streak and attributing the corresponding quality.

Table 1: Classification of the parameters considered.

PARÂMETERS		GREAT	GOOD	BAD
HUMIDITY (%)		< 3%	3 - 5%	> 5%
FIXED CARBON (%)		75 - 80%	81 - 85% e 74 - 70%	> 85% e < 70%
YIELDS (%)	GLOBAL	> 35%	35 – 32%	< 32%
	EFFECTIVE	> 32%	32 - 29%	< 29%

The calculations of yields are divided in two indices. It is the yields global (Y_{global}), that does not lead in consideration the charcoal produced, and of that form deduces the mass of the tiço (pre carbonized wood) of the total of wood in furnace. The Y_{global} expresses the efficiency of the process of carbonization, therefore alone tappet in count the mass conversion wood/charcoal. Another index is the yields effective ($Y_{effective}$), that does not deduce the mass of the tiço of the total of wood in furnace. The $Y_{effective}$ express the efficiency of the furnace, and that index is the most representative one for the comparisons between the approaches of control utilized in that work.

The comparisons between the furnaces were based us criteria listed above.

4. ANALYSIS RESULTS

It was carried out a total of sixteen furnaces, eight controlled by the inverse of frequency installed in the tar recovery device. In all those furnaces were deeds measurements of the data of the wood and of the charcoal produced. Also they were generated the graphics of temperature versus time, where was sought to establish a standard for the carbonization carried out in four similar kilns.

Utilizing itself the graduate valves as tool of control, were carried out eight carbonizations. The Table 2 presents the data of entrance and exit of those furnaces, as well like the results of yields and content of fixed carbon.

Table 2: Results of yields and content of fixed carbon of the furnaces that utilized graduate valves as tool of control.

FURNACE	WOOD MASS (kg)	WOOD UMIDITY (%)	TIÇO MASS (kg)	CHARCOAL MASS (kg)	CHARCOAL UMIDITY (%)	FIXED CARBON (%)	YIELDS (%)	
							GLOBAL *	EFFECTIVE **
01	58.772	37,8	8.300	8.160	4,6	85	27,4	23,3
02	66.523	17,5	2.030	19.930	4,2	79	36,2	34,8
03	78.330	36,3	1.000	13.450	5,7	77	25,9	25,4
04	70.201	19,3	13.130	14.540	4,2	71	31,9	25,4
05	61.910	21,9	1.924	16.850	5,6	76	34,3	32,9
06	65.198	14,1	6.270	15.400	4,5	83	29,5	26,2
07	65.138	15,0	2.462	18.310	5,6	81	32,5	31,1
08	80.454	13,4	5.557	16.180	4,3	85	24,1	22,1

$$* \quad Y_{global} = \left(\frac{charcoal\,mass_{dry\,base}}{wood\,mass_{dry\,base} - tiço\,mass} \right) \times 100$$

$$** \quad Y_{effective} = \left(\frac{charcoal\,mass_{dry\,base}}{wood\,mass_{dry\,base}} \right) \times 100$$

The great index for content of fixed carbon is between 75% and 80%, and for yields is more than 35% for Y_{global} and more than 32% for $Y_{effective}$. It is possible observe that barely two furnaces reach an index of $Y_{effective}$ above that value. As the content of fixed carbon is inversely proportional to the index of yields, it will be deemed barely a subjective relation between those values, since the index that better indicates the quality of a furnace is the yields, and the control is deemed based on production.

On the basis of those facts and comparing the high contents of fixed carbon obtained, medium of 80%, it is possible to infer that there were excessive burns in those furnaces, with the exception of the Furnaces 02 and 05 that presented a good relation between yields and content of fixed carbon.

However, to carbonization utilizing itself the graduate valves was shown difficult to control, and the carbonizator did not obtain accompaniment of the lower limits and superior of the curve, and with that it was not possible establish a relation between the opening of the valves and increase of temperature in the kiln.

The control through the graduate valves itself is based in the entrance of air to increase the temperature of the kiln through the burning of wood, or in the suppression of the air flow with the intention of diminishing the temperature of the kiln. That explains the short indices obtained in yields and the high indices obtained in fixed carbon.

For a better viewing of the dispersion of the behavior of the furnaces regarding the ideal behavior of the curve standard, the curves of temperature versus time of the eight furnaces were put in the even graphic one, Figure 3.

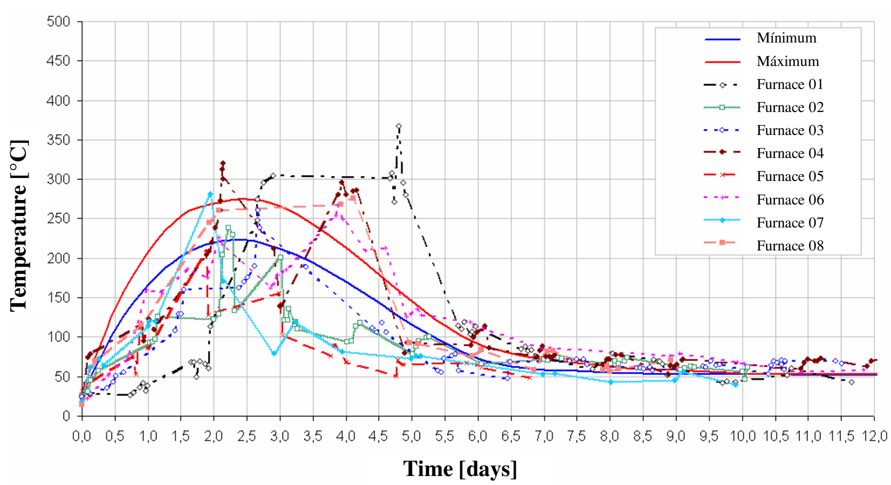

Figure 3: Curves of temperature versus time of the furnaces controlled by graduated valves.

It is observed at first that the objective of control the process was not achieved. For such, it is expected to obtain curves of temperature versus respective time that followed the same behavior in the long one of the cycle of drying and carbonization.

Another characteristic of the furnaces made with the valves is the color of the internal walls of the kiln, which can be seen even when it is open. In a typical furnace, they are presented in black, the result of the smokes expelled during the process of pyrolysis of the wood. However, when there is burns excessive of wood and combustion, the walls stayed with a whitish coloring. In all the furnaces made with the graduate valves the walls were presented with an undesired whitish coloring.

Utilizing itself the tar recovery equipped with inverse of frequency as tool of control, were carried out eight carbonizations. The Table 3 presents the data of entrance and exit of those furnaces, as well like the results of yields and content of fixed carbon.

Table 3: Results of yields and content of fixed carbon of the furnaces that utilized the tar recovery equipped with inverse of frequency as tool of control.

FURNACE	WOOD MASS (kg)	WOOD UMIDITY (%)	TIÇO MASS (kg)	CHARCOAL MASS (kg)	CHARCOAL UMIDITY (%)	FIXED CARBON (%)	YIELDS (%)	
							GLOBAL	EFFECTIVE
09	70.420	13,8	6.510	18.670	4,2	82	33,0	29,4
10	65.960	28,0	2.150	13.750	6,3	78	28,3	27,1
11	73.263	16,5	1.413	20.400	2,6	76	33,2	32,5
12	77.762	17,3	3.420	26.640	8,5	81	39,6	37,5
13	76.040	11,5	4.260	23.950	7,4	72	35,0	32,8
14	65.483	14,8	3.510	23.610	5,8	77	42,4	39,8
15	76.380	16,3	3.720	24.510	3,2	84	38,3	36,2
16	60.756	14,4	1.960	19.170	4,1	78	36,8	35,4

It is observed that all the furnaces obtained got indices of $Y_{efetivo}$ more than 29%, except the Furnace 10, that obtained short index of mass conversion wood/charcoal, probably due to the high moisture of the firewood enfurnace. Among those furnaces, six obtained $Y_{efetivo}$ more than 32%, which is the great index. Unlike the first furnaces, controlled by the valves, the results were satisfactory.

Since to Furnace 09, that was first to be charred with the tar recuperating device as a tool of control, was easy follow the temperature standard curve versus time, and this facility of control continued it happen in the furnaces following.

For a better viewing of the dispersion of the behavior of the furnaces regarding the ideal behavior of the curve standard, the curves of temperature versus time of the eight furnaces were put in an even graphic one, Figure 4. The difference between the curves of Figure 3 and Figure 4 is noticeable.

It is observed that the objective of controlling the process was achieved. It increase or diminish the medium temperature for follow the curve standard be obtained with extreme facility, in comparison with the necessary control for the same end with the valves.

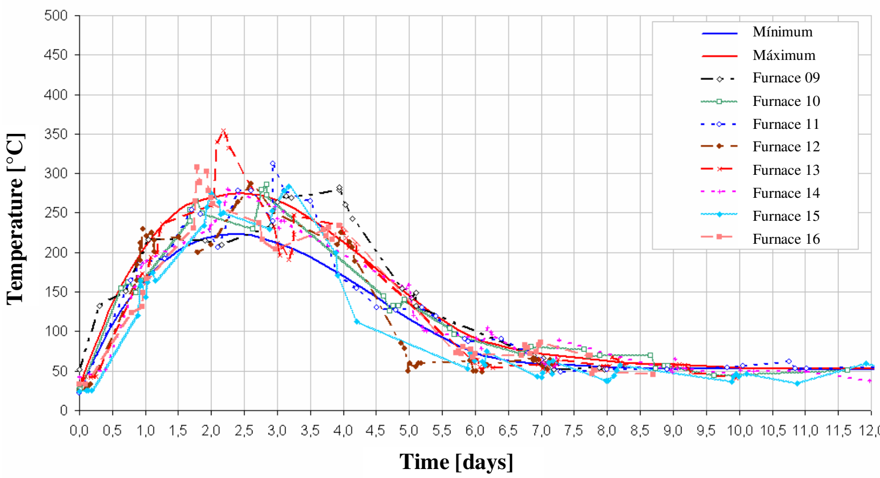

Figure 4: Curves of temperature versus time of the furnaces controlled by tar recovery device.

The control through the tar recovery is based in the suction of the hot gases to increase the temperature of the kiln through the acceleration of the process, or in the diminution of the suction, when the intention is going to diminish the temperature of the kiln. That explains the good indices obtained in yields, therefore the control of the furnace is not based in the burning of wood.

It observed itself, that upon opening the kilns, the color of the internal walls were presented well blackened, indicating that had not burns local in the bed of charcoal. Another one characteristic observed was that in the local where are found the exits of the valves, had not those 'holes' so characteristic in the furnaces controlled by the valves.

Those facts are indicative of the diminution of the burning of wood, shown up by the high rate of mass conversion wood/charcoal.

5. CONCLUSION

The analysis of viability of the tools of control utilized for the control of the process of carbonization itself based mainly in the facility of operation and in the repeatedly of the control, beyond the index of yields effective, which express better the efficiency of a furnace.

The valves were shown impracticable in the control of the process, presenting:

- Excessive Burning of wood in the localities where were installed;
- Difficulties of operation, given to extensive configuration possibilities range of the four available valves;
- The walls of the kilns presented clear color, showing burning in the bed of charcoal;
- Diminution or maintenance of the indices of yields;
- Difficulty of cleaning of the pipes, causing obstructions and consequent loses of shipment.

The control made through the tar recovery device presented:

- Burning done not locate of wood, showing up a bigger homogeneity of the process;
- Facility of operation, have seen that the circulation of the gases is unique and the operation of the inverse of frequency is simple;
- The walls of the kilns it left to present clear color, that shows up the burning in the bed of so undesirable charcoal;
- Increase of the indices of yields.

The indexes of yields and content of fixed carbon are consequence of a more homogeneous control, where one seeks to avoid peaks of temperature to the long one of the time, accompanying a curve standard. The furnaces controlled by the tar recovery device presented indices of yields medium of 34%, around 18% bigger than the furnaces controlled by the valves, that presented yields medium of 28%. That profit in the mass conversion wood/charcoal is turned out of the diminution of the burning located of wood, that was common in the control with the valves.

As regards the indices of mechanical resistance, insignificant variation between the furnaces was noticed controlled by the valves regarding the furnaces controlled by the tar recovery device.

Also it was not noticed that an improvement of the productivity that was expressed by the number by day that hard to furnace. The furnaces lasted around 12 days, considering itself the total cycle (drying, carbonization and refrigeration), days those verified so much in the furnaces controlled by the valves, as much as by the furnaces controlled through the variation of the motor of the tar recovery device.

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