# THE USE EVALUATION OF HOT GASES ORIGINATING FROM TAR BURNS IN THE CARBONIZATION PROCESS IN RECTANGULAR KILNS OF V&M FLORESTAL FOR THE WOOD DRYING PROCESS

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***Abstract.*** *The present work presents a summary of the activities developed in V&M Florestal on 2006 on a project in partnership with UFMG. In this context it was studied tar burn as energy source for the wood carbonization process in industrial kilns FR190. A tar burner system used was developed by IPT/V&M Florestal for the generation of hot gases. These hot gases were injected in kilns. This work objective is the V&M Florestal carbonization process improvement with an increase of the kilns productivity and yield through the analysis of the use of the hot gases originating from tar burns for the wood heating and drying. The injection of the resulting gases of the tar burns diluted in atmospheric air to inferior temperatures to 200°C for the wood drying was evaluated. An increase on yield was observed for superior times of drying at 30 hours, the most significant increase was obtained for 60 hours of drying.*

**Keywords:** tar combustion, carbonization process, rectangular kiln.

## 1. INTRODUÇÃO

The carbonization process of the biomass consists in heating the biomass to superior temperatures of 200°C in a inert atmosphere, modifying its components and unfastening water vapor, organic liquids, not condensable gases and remaining charcoal as product, being the amount and characteristics of the produced charcoal dependents of the characteristics of used wood and of the conditions of the process.

The not condensable gases are composites by carbon monoxide, carbon dioxide, hydro-carbons and hydrogen. The organic liquids resultants in carbonization process are the pyre acid and the tar. The pyre acid contains 80% of water, the remain can be identified by ascetic acid, formic acid, prop ionic acid, methanol, formaldehyde, acetone and soluble tar (dissolved in ascetic acid). The insoluble tar is a complex substance mixture. The products of the vacuum distillation of the tar can be seen in Tab. 1. Beyond its use as combustible, many of substances in the composition of the tar are of interest of chemical and pharmaceutical industries.

Table 1. Products of the vacuum distillation of the tar (Nogueira, 2000)

| Phenol | O-cresol | M2p-cresol | Xylenol | Guaiacol | Methyl guaiacol | Phenols with high boiling point | Residuals phenols | Total [%] |
|---|---|---|---|---|---|---|---|---|
| 4.04 | 4.04 | 5.53 | 12.82 | 13.51 | 5.81 | 42.20 | 12.05 | 100.00 |

In V&M do Brasil, the charcoal is used as term-reducer agent in the blast furnaces for the production of the fused iron. Part of this charcoal, used in the production of the fused iron, is produced by V&M Florestal. In V&M Florestal the charcoal is produced in rectangular kilns FR-190. Each kiln is built with metallic structures of sustentation and walls of bricks and mud. The doors are also metallic, covered internally with refractory concrete. The wall of the bottom has a window at the top for the relief of the pressures. The floor is of beaten soil. For the control of the inlet there are four drawer type valves placed side by side in the ground. For outlet, that may be central circulation in the ground or lateral circulation in the wall, there is a T type piping endowed with drawer type valves that tie the chimney and the recuperador tar equipment. These kilns have dimensions of 16x4x4.5m. Eucalyptus wood is used as raw material for the carbonization process. The wood logs are put into the kiln with the length of 3,60m disposed in four stacks guided in the longitudinal sense of the kiln. The complete cycle of the process is about 12 days, being composed by the stages of shipment of the wood, ignition, drying and carbonization of the wood, cooling of the charcoal and discharge of the charcoal. The process is not uniform inside the kilns due to the geometric characteristics of the kilns and of the wood stacks. Figure 1 displays some kilns FR-190 of a carbonization plant of V&M Florestal.

Figure 1. Kilns FR-190 of a carbonization plant of V&M Florestal.

After the cut, the wood dry in the field for a period from 90 to 120 days before be taken to the kilns. Therefore, the wood is put into the kiln with humidity from 15 to 30% in humid base. The ignition of the wood inside the kilns is accomplished through a small opening in the lateral wall of the kilns denominated "tatu". The energy for the drying and beginning of the wood carbonization process is removed from the combustion of part of the wood into the kiln. After the beginning of the carbonization, the process is exothermic and, therefore, sustainable by itself. During the carbonization period, a tar recuperator equipment connected to the chimney of the kilns is on sucking the resultant gases of the carbonization process and condensing part of the tar contained in these gases. Figure 2 shows the ignition of the wood in a kiln FR-190 by a “tatu”. Figure 3 presents a tar recuperator equipment used in the carbonization process of V&M Florestal.

Figure 2. Ignition of the wood in a kiln FR-190 by a “tatu”.

Figure 3. Tar recuperator equipment used in the carbonization process of V&M Florestal.

It is intended with this study, to verify the influence of the injection of hot gases from tar burns diluted in atmospheric air, to inferior temperatures to 200°C, to supply the necessary energy for the wood drying before the

carbonization process begins in the kilns FR-190. The experiments were accomplished in Itapoã carbonization plant. With this objective, gases of the tar combustion diluted in atmospheric air were injected to inferior temperatures to 200°C seeking the wood drying before the ignition. The increase in yield of the process and productivity of the kilns were evaluated. For the injection of the hot gases in the kilns a system of tar combustion, developed by IPT/V&M Florestal, was used.

The present work has as objectives to evaluate the earnings in yield of the process and productivity of the kilns FR-190 with the injection of hot gases to inferior temperatures to 200°C for the wood drying before the beginning of the carbonization process.

## 2. TAR COMBUSTION SYSTEM FOR HOT GASES GENERATION

Fig. 4 shows the tar combustion system for hot gases generation.

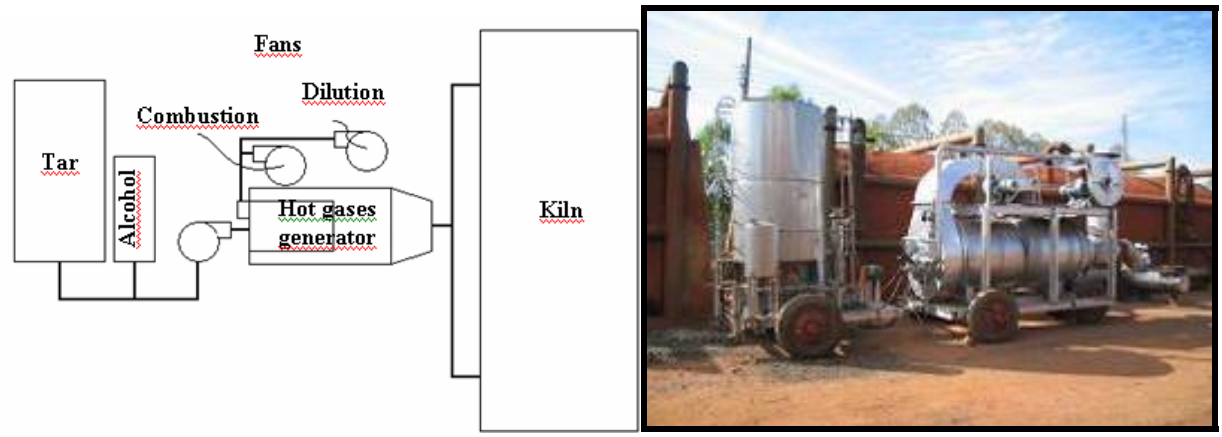


Figure 4. Tar combustion system for hot gases generation.

This system consists in three sub-systems:

- Subsystem for fuel supply;
- Subsystem for air supply;
- Subsystem for hot gases generation;

The subsystem for fuel supply is composed by a tank of tar, a tank of alcohol and a cylinder of GLP. GLP is used for the maintenance of a pilot fire. The alcohol is used for the heating of the system before the injection of the tar. The tanks of alcohol and tar are linked to the fuel pump connected to the injection beak. This pump possesses a frequency investor for the control of the fuel flow.

The subsystem for air supply is composed by two fans, one for the combustion air, with motor of 25cv and other for the dilution air, with motor of 30cv. The dilution air is mixed to the combustion gases for the control of the temperature and flow. A frequency inverter is tied on dilution fan for the flow control.

The subsystem for hot gases generation is composed by a combustion chamber and an injection beak. In the injection beak, the fuel is sprayed in the center while the combustion air is injected in turn of the powdered fuel. The dilution air is mixed to the gases before of it burns inside the combustion chamber, controlling the temperature and flow of the exit of gases from the tar combustion system. The temperature can also be controlled by the flow of fuel.

## 3. METHODOLOGY

Three tests were accomplished for the wood drying. These three tests were accomplished in the same kiln, being the yield results and productivity compared with batches accomplished in the same kiln without the injection of hot gases.

The gases were injected in the extremities of the lateral walls of the kiln with the circulation for the central chimney in the floor, searching the gases circulation shown in Fig. 5.

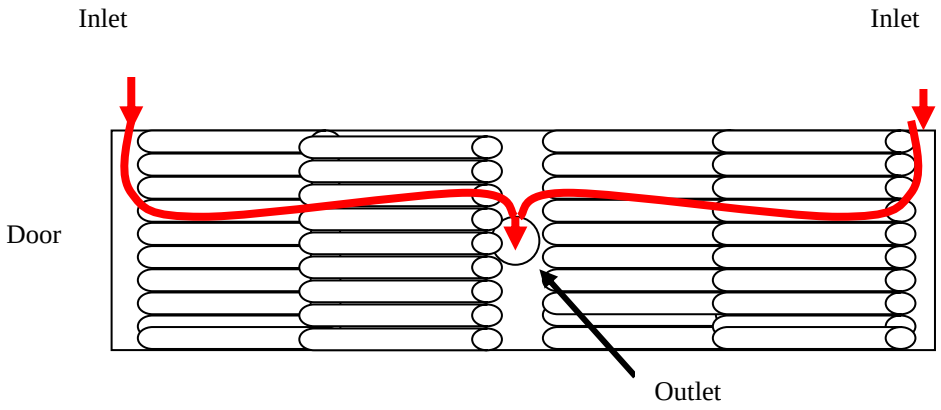


Figure 5. Flow circulation used for the tests (upper view of the kiln).

During the tests it was used a fuel flow of 50kg/h, a combustion air flow of 0,16kg/s and a dilution air flow of 2,5kg/s. The total gases flow injected in the kiln during the tests was of 2.7 kg/s.

The first test was accomplished between 03 and 06/10/2006 when were totaled 66 continuous hours of gases injection with the inlet temperature in the kiln between 150 and 160°C. The second test was accomplished between 24 and 26/11/2006 totaling 32 hours and forty minutes of continuous gases injection. The temperature of the inlet in the kiln varied between 145 and 155°C. Finally, the third test was accomplished between 12 and 13/12/2006 totaling 34 hours of continuous gases injection with temperatures between 150 and 170°C.

## 4. RESULTS

The results obtained for the wood drying is showed in Tab. 2. For the analysis of these results, these were compared with results of carbonization processes at the same kiln where the wood drying was not accomplished, showed in Tab. 3.

Table 2. Results obtained for the carbonization process with the wood drying.

| Test | Ignition date | Injection temperature [$^{o}$C] | Injection time [h] | Yield [%] | Carbonization time [Days] |
|---|---|---|---|---|---|
| 1 | 06/10/2006 | 155 | 66 | 39.8 | 1.2 |
| 2 | 26/11/2006 | 150 | 32.75 | 26.7 | 1.5 |
| 3 | 12/12/2006 | 155 | 34 | 28.4 | 1.5 |

Table 3. Results obtained for the carbonization process without the wood drying.

| Batch | Ignition date | Yield [%] | Carbonization time [Days] |
|---|---|---|---|
| 1 | 24/5 | 21.3 | - |
| 2 | 15/6 | 24.4 | - |
| 3 | 20/7 | 22.4 | 2 |
| 4 | 25/8 | 21.6 | 3 |
| 5 | 14/9 | 24.4 | 3 |

Five batches were accomplished in the same kiln without the injection of hot gases, where the medium yield was of 22.8% as shown in Tab. 3. The results of the carbonization processes on batches where the wood drying was made were compared with the processes were the drying process was not made. It is noticed an increase in the yield for the batches where the wood drying was made. In the tests 2 and 3 shown in Tab. 2, a small increase of the yield was observed, in test 2 the yield was about 26.7%, and in test 3 the yield was about 28.4%. In the test 1, where there was a larger time of drying, a more representative increase was observed in the yield, that was about 39.8%.

It was also observed a decrease in the time of carbonization in the batches where the drying of the wood was accomplished, being this about 1.5 days in these batches. The batches where it didn't take place the drying showed a medium time of carbonization of 3 days.

During the first test great amount of water could be observed condensed in the instrumentation tubes of the kiln, demonstrating an effective loss of wood humidity during the gases injection process.

The data of the charred wood and of the charcoal produced in the tests for the wood drying can be seen in Tab. 4.

Table 4. The input and output data of the three tests.

| | | Test 1 | Test 2 | Test 3 |
|---|---|---|---|---|
| Wood | Mass [kg] | 65500 | 54000 | 69000 |
| | Species | Cloeziana | Urophyla | Cloeziana |
| | Humidity [%] | 14.8 | 34.4 | 23.3 |
| | Diameter [cm] | 6.7 | 7.9 | 11.3 |
| Charcoal | Mass [kg] | 24000 | 11000 | 17000 |
| | Humidity [%] | 5.8 | 10.5 | 10.4 |
| Global | Yield [%] | 39.8 | 26.7 | 28.4 |
| | Fix carbon [%] | 73.9 | - | - |
| Tiço | Mass [kg] | 3510 | 1580 | 6290 |

As it can be seen in Tab. 4, there are differences in the characteristics of the wood put into the kiln in each drying test accomplished. These characteristics, as the wood mass, the eucalyptus species, the humidity and the medium diameter, can influence in the process and in the carbonization products.

## 5. CONCLUSIONS

For the three wood drying tests, an increase of the yield was observed being compared with the batches where the wood drying was not accomplished. For the batches with about thirty hours of drying, an increase was observed in the yield of about 22.5% for about 27.5%. For the batch with sixty hours of drying, this yield arose for 40%. In the three tests a decrease was observed in the time of carbonization on average of three days for about two days of carbonization.

An increase in the yield compatible with what was observed for 60 hours of drying would generate a substantial increase in the productivity of the kilns, even with the increase of the cycle of these kilns. This result must, therefore, be evaluated better by the fact of just one test it was accomplished for this time of drying.

## 6. REFERENCES


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