PORTLAND CEMENT PRODUCTION WITH DREGS AND GRITS FROM KRAFT PULP MILLS INCORPORATION TO THE CLINKER

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INTRODUCTION

It is estimated that in 2016 in Brazil were generated:

- 282,000 tons of Dregs
- 94,000 tons of Grits
INTRODUCTION

Dregs, originated from green liquor clarification are impurities originating mainly from carbon, hydroxides and metal sulfides with pH approximately 11 and generated of up to 15 kg.adt\(^{-1}\) of pulp produced.
INTRODUCTION

Grits, originated in the slakers are composed of unreacted lime with pH approximately 11 and generation of up to 5 kg.adt$^{-1}$ of pulp produced
INTRODUCTION

Green Liquor

Clarification of Green Liquor

Dregs

Filtration

Causticizers

Grits

Lime mud filter

White liquor storage tank

Weak white liquor

Lime

lime

limestone

Lime mud tank

Lime kiln

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INTRODUCTION
INTRODUCTION

The Brazilian market has 8 cement options

The factors that differentiate the types of cement are the addition in the process of grinding different proportions of Clinker, calcium sulphates, carbonatic material and additions (slag, pozzolans and calcareous)

- Cimento Comum (CP I)
- Cimento Composto (CP II)
- Cimento de Alto-Forno (CP III)
- Cimento Pozolânico (CP IV)
- Cimento de Alta Resistência Inicial (CP V-ARI)
- Cimento Resistente a Sulfatos (RS)
- Cimento de Baixo Calor de Hidratação (BC)
- Cimento Portland Branco (CPB)
OBJECTIVES

This paper proposes the incorporation, in different proportions (2.5; 5; 7.5; 10 and 15%), of alkaline solid wastes from pulp mills, namely dregs and grits, to clinker in the cement industry.
MATERIAL AND METHODS

Dregs and grits were obtained from a Brazilian bleached kraft pulp mill

Clinker was obtained from a Brazilian cement

These materials were characterized in the laboratories of the Federal University of Vicosa – UFV and the Federal University of Minas Gerais – UFMG
MATERIAL AND METHODS

The dregs and grits were submitted to an experimental path described by the flowchart.
Dregs / Grits / Clinker

Drying
Milling
Sieving

Mixture Percente of Dregs + Clinker
Grits + Clinker

Soundness by the Le Chatelier

Determination of the paste with normal consistency

Compressive Strength

Elasticity Modulus

Setting Times

Characterization

Physical

Specific Mass
Specific Area
Fineness
SEM

Chemical

EDX
EDS
XRD
Pozzolanic
TG/DTG

0%
2.5%
5%
7.5%
10%
15%

Cold
Hot

3 days
7 days
28 days
In the present research for each incorporation of dregs and grits (2.5; 5; 7.5; 10 e 15%) to the clinker

**Dosage materials for experimental clinker**

<table>
<thead>
<tr>
<th>Samples</th>
<th>Series</th>
<th>Trace (%)</th>
<th>Amount of specimens</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Cliker</td>
<td>Dose</td>
</tr>
<tr>
<td>CPo - 0</td>
<td></td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td><strong>Dregs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CPd - 2.5</td>
<td></td>
<td>97.5</td>
<td>2.5</td>
</tr>
<tr>
<td>CPd - 5.0</td>
<td></td>
<td>95.0</td>
<td>5.0</td>
</tr>
<tr>
<td>CPd - 7.5</td>
<td></td>
<td>92.5</td>
<td>7.5</td>
</tr>
<tr>
<td>CPd - 10.0</td>
<td></td>
<td>90.0</td>
<td>10.0</td>
</tr>
<tr>
<td>CPd - 15.0</td>
<td></td>
<td>85.0</td>
<td>15.0</td>
</tr>
<tr>
<td><strong>Grits</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CPg - 2.5</td>
<td></td>
<td>97.5</td>
<td>2.5</td>
</tr>
<tr>
<td>CPg - 5.0</td>
<td></td>
<td>95.0</td>
<td>5.0</td>
</tr>
<tr>
<td>CPg - 7.5</td>
<td></td>
<td>92.5</td>
<td>7.5</td>
</tr>
<tr>
<td>CPg - 10.0</td>
<td></td>
<td>90.0</td>
<td>10.0</td>
</tr>
<tr>
<td>CPg - 15.0</td>
<td></td>
<td>85.0</td>
<td>15.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>132</strong></td>
<td></td>
</tr>
</tbody>
</table>
MATERIAL AND METHODS

For each dose, four specimens were tested in each age (3, 7 and 28 days). The elasticity modulus test was carried out only in the last three specimens.

The used universal testing machine was a EMIC, model DL600KN compressive strength and elasticity modulus.
## RESULTS AND DISCUSSION

### EDX of clinker, dregs and grits

<table>
<thead>
<tr>
<th></th>
<th>CaO</th>
<th>SiO₂</th>
<th>Al₂O₃</th>
<th>Fe₂O₃</th>
<th>SO₃</th>
<th>MgO</th>
<th>K₂O</th>
<th>Na₂O</th>
<th>TiO₂</th>
<th>Cl</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinker (%)</td>
<td>64.55</td>
<td>20.65</td>
<td>3.02</td>
<td>3.23</td>
<td>1.00</td>
<td>0.33</td>
<td>1.47</td>
<td>1.71</td>
<td>0.27</td>
<td>0.07</td>
<td>3.72</td>
</tr>
<tr>
<td>Dregs (%)</td>
<td>68.85</td>
<td>6.67</td>
<td>0.74</td>
<td>3.27</td>
<td>6.44</td>
<td>3.14</td>
<td>0.91</td>
<td>3.64</td>
<td>0.18</td>
<td>0.39</td>
<td>5.78</td>
</tr>
<tr>
<td>Grits (%)</td>
<td>83.36</td>
<td>5.21</td>
<td>0.29</td>
<td>1.16</td>
<td>0.97</td>
<td>0.66</td>
<td>0.50</td>
<td>2.77</td>
<td>0.08</td>
<td>0.27</td>
<td>4.73</td>
</tr>
</tbody>
</table>
SEM Dregs

EDS Dregs

SEM Grits

EDS Grits
## Results of material characterization tests

<table>
<thead>
<tr>
<th>Tests</th>
<th>Consistency A(%)</th>
<th>Setting Times (h:min)</th>
<th>Soundness by the Le Chatelier (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Stard</td>
<td>End</td>
</tr>
<tr>
<td>Clinker</td>
<td>30.88</td>
<td>1:45</td>
<td>2:40</td>
</tr>
<tr>
<td>Dregs</td>
<td>---</td>
<td>1:55</td>
<td>2:47</td>
</tr>
<tr>
<td>2.5% Dregs</td>
<td>---</td>
<td>1:15</td>
<td>2:15</td>
</tr>
<tr>
<td>5.0% Grits</td>
<td>---</td>
<td>1:30</td>
<td>2:45</td>
</tr>
<tr>
<td>7.5% Dregs</td>
<td>---</td>
<td>1:11</td>
<td>2:43</td>
</tr>
<tr>
<td>10.0% Grits</td>
<td>---</td>
<td>1:40</td>
<td>3:26</td>
</tr>
<tr>
<td>15.0% Dregs</td>
<td>---</td>
<td>0:32</td>
<td></td>
</tr>
</tbody>
</table>

Limits:  
- Normal Consistency: A(%)  
- Setting Times: h:min  
- Soundness by the Le Chatelier: mm  
- Limits:  
  - Normal Consistency: A(%) 
  - Setting Times: h:min 
  - Soundness by the Le Chatelier: mm 
  - Limits: 
    - Normal Consistency: ≥ 1h 
    - Setting Times: ≤ 10hs 
    - Soundness by the Le Chatelier: ≤ 5
<table>
<thead>
<tr>
<th>Tests</th>
<th>Specific mass (g/cm³)</th>
<th>Specific Area (m²/kg)</th>
<th>Fineness (%)</th>
<th>Pozzolanic (mS/cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinker</td>
<td>3.00</td>
<td>246</td>
<td>0.26</td>
<td>0.98</td>
</tr>
<tr>
<td>Dregs</td>
<td>2.44</td>
<td><strong>1031</strong></td>
<td>0.78</td>
<td>0.87</td>
</tr>
<tr>
<td>Grits</td>
<td>2.67</td>
<td><strong>972</strong></td>
<td><strong>95.20</strong></td>
<td>0.31</td>
</tr>
<tr>
<td><strong>Dregs</strong></td>
<td></td>
<td></td>
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<td><strong>---</strong></td>
</tr>
<tr>
<td><strong>2.5%</strong></td>
<td></td>
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</tr>
<tr>
<td>Grits</td>
<td>3.05</td>
<td>325</td>
<td>1.28</td>
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<tr>
<td><strong>Dregs</strong></td>
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<td><strong>---</strong></td>
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<tr>
<td><strong>5.0%</strong></td>
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<tr>
<td>Grits</td>
<td>3.01</td>
<td>306</td>
<td>2.46</td>
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<tr>
<td><strong>Dregs</strong></td>
<td></td>
<td></td>
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<td><strong>---</strong></td>
</tr>
<tr>
<td><strong>7.5%</strong></td>
<td></td>
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</tr>
<tr>
<td>Grits</td>
<td>2.99</td>
<td>301</td>
<td>5.36</td>
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<tr>
<td><strong>Dregs</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>---</strong></td>
</tr>
<tr>
<td><strong>10.0%</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Grits</td>
<td>3.00</td>
<td>361</td>
<td>2.72</td>
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</tr>
<tr>
<td><strong>Dregs</strong></td>
<td></td>
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<td><strong>---</strong></td>
</tr>
<tr>
<td><strong>15.0%</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grits</td>
<td>2.95</td>
<td>352</td>
<td>3.96</td>
<td></td>
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<tr>
<td><strong>Limits</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>≥ 245</td>
<td>≤ 12</td>
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</tbody>
</table>
The results of the **COMPRESSIVE STRENGTH TESTS** on four of the percentages **Dregs and Grits** 3, 7 and 28 days of age.

![Compressive Strength (Dregs)](image1)

![Compressive Strength (Grits)](image2)
The results of the **ELASTICITY MODULUS TESTS** on four of the percentages **Dregs and Grits** 3, 7 and 28 days of age.
CONCLUSIONS

The physical-chemical characterization of dregs and grits showed a great potential to use these materials for incorporation into the clinker Portland cement production.

The different incorporation of dregs and grits (2.5; 5.0; 7.5 and 10%) to the clinker proved viable for ordinary Portland cement production with addition (CP I-S) and Portland composite cement (CP II-F).
CONCLUSIONS

The incorporation of both materials to clinker fulfilled the minimum limits for the compressive strength test and modulus of elasticity established by the Brazilian standard.

Grits showed, in general, better results than Dregs.
REFERENCES

BRAZILIAN ASSOCIATION OF TECHNICAL NORMS. NBR NM 23: Determination of density. 1 ed. Rio de Janeiro. 2001. 5p. (available only in Portuguese)


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Questions?
Thank you!

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