Reducing the energy consumption for recycling cement: shifting from a wet method to an air-blowing method

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Keywords: cement, recycled cement, production methods, energy consumption, carbon emissions.
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Amongst the many challenges faced by mankind nowadays, excessive consumption of non-renewable resources and pollution are two of the most relevant. These two challenges are, in many cases, directly connected, with the consumption of non-renewable resources being, in most cases, also a source of pollution. One of such cases is the construction industry in general, and the concrete industry in particular. With an estimated consumption of over 30 billion tons per year, concrete ranks second in terms of the most consumed materials in the world after water (WBCSD 2009). This means that it is the most consumed artificial material worldwide, implying the consumption of large amounts of non-renewable resources in its production. In addition to the pollution during the production stage, concrete makes up a significant portion of the more than the 3 (Akhtar and Sarmah 2018) to 10 (Wu et al. 2019) billion tons of construction and demolition waste generated annually.

The energy consumption of the cement industry represents 2% of global primary energy consumption or about 5% of total global industrial energy consumption (Hendriks et al. 1998). At the same time, the resulting carbon emissions makes cement production the third largest source of anthropogenic emissions of carbon dioxide (CO_2), after fossil fuels and land-use changes, being responsible for 8% of the total emissions worldwide (Andrew 2018). Carbon emissions are, therefore, one of the most significant, if not the most significant, environmental impact directly associated with cement production and, indirectly, to the use of concrete (BIO 2011).

Recycling cement from construction and demolition waste allows tackling both these challenges simultaneously by creating a closed-loop-recycling (ECRA 2017), contributing significantly towards the circular economy plan devised in the EU (EC 2020). In Europe, this solution would also contribute towards: i) meeting the goal of reusing, recycling or recovering a minimum of 70% (by weight) of non-hazardous construction and demolition waste, excluding naturally occurring material (article 11.2 of the Waste Framework Directive (EC 2008)); and ii) meeting the green deal targets (CEMBUREAU 2020) by the partial or total replacement of Portlant clinker by recycled cement (RC).

This research effort builds on an ongoing research line carried out at IST, in particular the energy consumption necessary for RC production assessed by Sousa and Bogas (2021). The results obtained reveal that the need for washing and drying the material before separating the cement paste from the aggregates is responsible for the consumption of the largest portion of the total thermal energy required for producing recycled cement. As such, alternative solutions were explored to avoid the need for this washing and drying, namely by using air to remove the dust from the particles and increasing the power of the magnetic separator.

The results presented in Table 1 and 2 reveal that the energy consumption of the RC air-blowing cleaning production method is roughly 25% of the RC wet cleaning production method and the emissions even less.

Table 1 – Estimated energy consumption and carbon emissions from RC production with the water cleaning

STAGE	WORLD	EUROPE	PORTUGAL	
			AVERAGE	SECIL
ENERGY [MJ / t RC]				
Drying	6299.6			
Reactivation	1189.0	1255.3	1272.0	1147.4
Electricity	964.0	713.5	1005.8	845.1
Transportation	-	-	162.2	81.1
Total	*8452.6*	*8268.4*	*8739.6*	*8373.2*
EMISSIONS [kg CO_2/ t RC]				
Drying	574.2	501.8	491.2	425.0
Reactivation	108.4	100.3	92.7	80.2
Electricity	127.2	42.8	55.4	46.6
Transportation	-	-	34.9	17.4
Total	*809.7*	*644.9*	*674.2*	*569.2*

Table 2 – Estimated energy consumption and carbon emissions from RC production with the air-blowing cleaning

STAGE	WORLD	EUROPE	PORTUGAL	
			AVERAGE	SECIL
ENERGY [MJ / t RC]				
Drying	-			
Reactivation	1201.1	1268.1	1284.9	1159.1
Electricity	736.3	557.2	766.2	651.3
Transportation	-	-	163.9	82.0
Total	*1937.4*	*1825.3*	*2215.0*	*1892.4*
EMISSIONS [kg CO_2/ t RC]				
Drying	-	-	-	-
Reactivation	109.5	101.3	93.7	81.0
Electricity	97.2	33.4	42.2	35.9
Transportation	-	-	35.2	17.6
Total	*206.6*	*134.7*	*171.1*	*134.5*

Acknowledgements

The authors wish to thank the Portuguese Foundation for Science and Technology (FCT) for funding this research under the project PTDC/ECI-COM-28308/2017 EcoHydB: Eco-efficient hydraulic binders produced from waste cement-based materials and under the unit project UIDB/ECI/04625/2020 of CERIS.

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