Application of Kiln Gas Bypass Dust at the Slacked Lime Process of Leather Production

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Abstract

The application of fractions of industrial and/or domestic waste at the cement industry as a substitute to fossil fuels leads to an increased production of byproduct dusts. Such byproduct dusts contain valuable fractions for other industry branches. For the leather production industry e.g. the content of about 40% free lime (CaO) could be very interesting. Hence trials about the applicability of byproduct dusts, in detail kiln gas bypass dust, for the slacked lime process has been done. The outcomes have been surprising, because besides the substitution of lime hydrate, a direct positive influence between the substitution rate and the leather texture properties has been observed. It's expected that such effects are strongly related to the salt content of the kiln gas bypass dust.

Introduction

The cement industry is an important base material producing sector. It produces cement clinker, the precursor of cement, mortar, and concrete. In our days cement is ubiquitously, and very hard to replace. Hence the cement production of a country is a significant indicator for its economic standing. The production of cement clinker consumes a lot of fossil energy. Therefore alternative energy sources are growing in importance. At today's state of the art, a part of the fossil energy is replaced by fractions of industrial and/or domestic waste. The chemical shift of the fuel composition leaded also to a chemical shift of the exhaust dust composition. In older days the exhaust dust was totally recycled by blending it to the cement. Today's exhaust dust addition to blends is regulated by its chloride content. The chloride occurs mainly as potassium chloride (KCl) and sodium chloride (NaCl). Traces of other chlorides, like LiCl, $CaCl_2$, $MgCl_2$,..., are also present. The origins of these minerals are on the one hand the mineral raw materials, and on the other hand the fuels. As mentioned previously fossil fuels are replaced by waste, which contains much more of chloride substances.

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The exhaust dust type of the highest chloride content is the so called kiln gas bypass dust (*cf. Figure 1*). Here a part of the kiln gas including its dust is extracted from the process to reduce undesired elements in the kiln process. Such undesired elements are alkalies, sulfur, and chlorine. Kiln gas bypass dust contains usually a chlorine fraction higher than 5 % ($^{m}/_{m}$). Hence mainly kiln gas bypass dust is problematic to add to cement blends. Usually the surplus of cement kiln gas bypass dust has to be deposed, which is on the one hand difficult and on the other hand very expensive. Hence there is a big demand for applications which can use such kind of dust as a raw material.

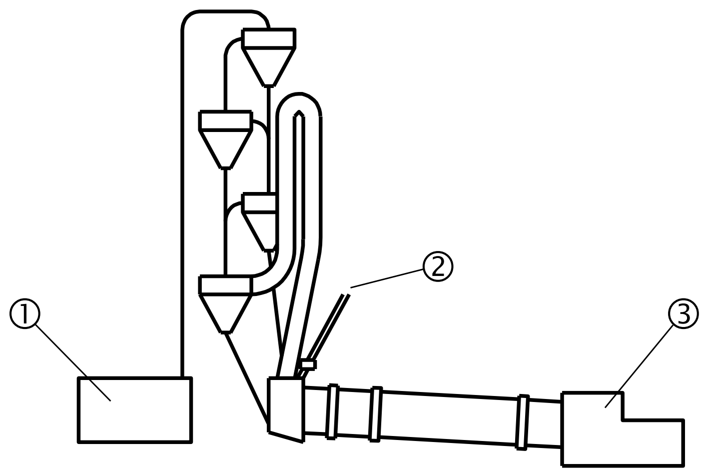

Figure 1 : different exhaust dust sources; (1) *main-filter dust,* (2) *kiln gas bypass dust,* (3) *cement clinker dust*

Unfortunately the exhaust dusts are mixtures, usually of lime stone (0 - 10 %), quick lime (15 - 45%), silica (10- 40 %), alumina (1 - 5 %), ferrates (1 - 5 %), and well soluble salts (5 - 25 %). There are only a few industries which apply more than one of these components in their processes.

A TEC Production & Services GmbH, an engineering company with lots of experience in the cement process was looking for an application at the leather production industry. A TEC found a valuable partner for this project with the Höhere Bundeslehr- und Versuchsanstalt für chemische Industrie (College for Chemical Engineering) “Rosensteingasse”, where all the practical trials finally took place.

Proceedings

The basis for this work is the fact that kiln gas bypass dust contains up to 40 % of quick lime. *Table 1* gives an overview of the average kiln gas bypass dust composition applied for the trials. Quick lime and lime hydrate respectively, are applied for the slacked lime process at the leather production. The slaked lime process is just one part of the leather production process, but its success or fail defines the latter quality of the leather, especially the texture behavior.

Table 1 : average composition of the applied kiln gas bypass dust[1]

Components	Ratio [% $^{m}/_{m}$]
CaO (quick lime)	41,7 %
SiO_2	10,6 %
$Al_2O_3 + Fe_2O_3$	4,5 %
S	1,3 %
Cl	6,7 %
K	7,9 %
Na	0,5 %
miscellaneous	balance

Three production lines have been used in parallel to observe every change of the leather behavior. *Figure 2* gives a brief summary of the applied leather production line. The first line, the reference line, applied normally used lime hydrate. The second line applied a CaO content based mixture of 50 % CaO from lime hydrate and 50 % CaO from kiln gas bypass dust. The third line applied the same amount of CaO as the other two lines, but this time completely as kiln gas bypass dust. The raw skin was from goat and preserved with salt. Every single piece of skin was marked by slices and divided to the three process lines. By this procedure the natural diversity of skin behavior was equalized. The skins at all three lines have been exactly treated by the same recipe for clothing velours leather.

1 The kiln gas bypass dust was kindly provided by Wietersdorfer & Peggauer Zementwerke GmbH, Plant Wietersdorf; Wietersdorf 1, A-9373 Klein St.Paul, AUSTRIA

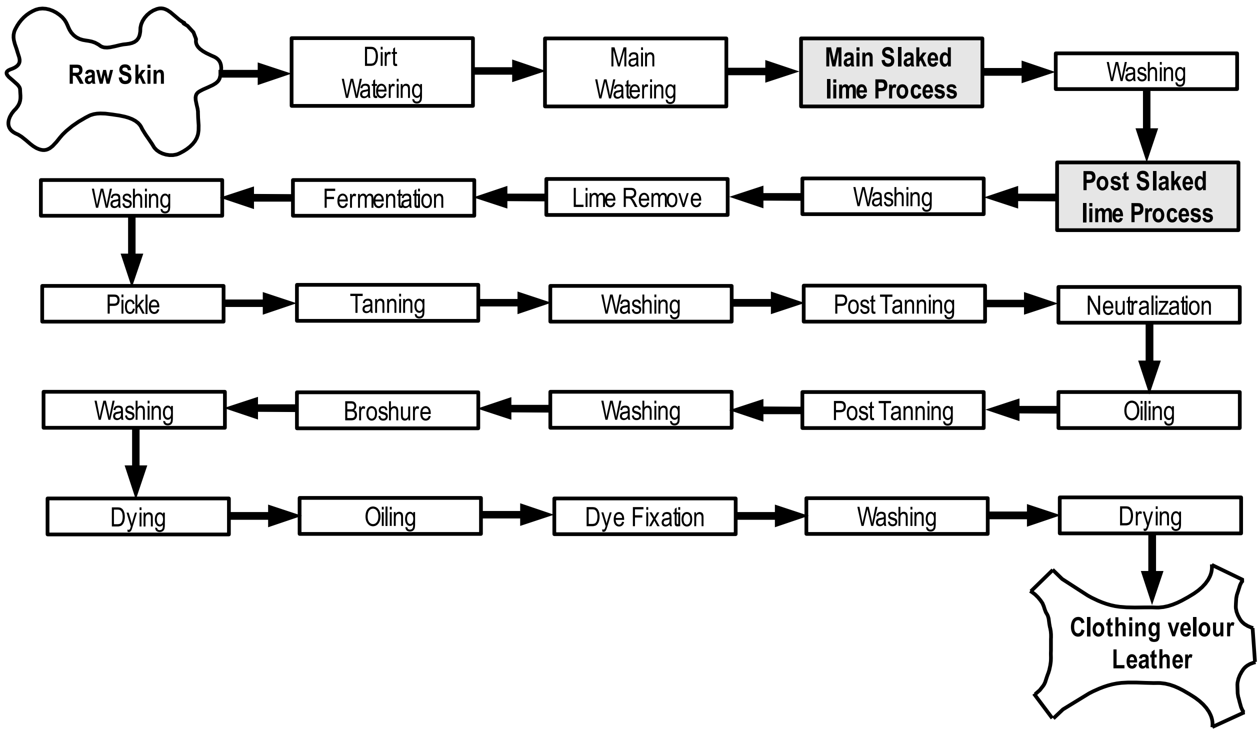

Figure 2 : A brief summary of the applied leather production line of these trials.

Results

Processibility

About 45 % of the kiln gas bypass dust are insoluble. Hence more material is required to fulfill the request of free lime or lime hydrate respectively. Subsequently it is more difficult to handle the liquor of the slaked lime process than using lime hydrate only. The insoluble material together with the decomposed fur forms a heavy slurry inside the slaked lime process barrel. The barrel is difficult to purge with this slurry. It can cause problems also at the drain an later at the sewage treatment.

Leather Behavior

Surprisingly the textural behavior of the finished clothing velour leather has been influenced in a clear relation to the amount of the applied kiln gas bypass dust. The *figures 3, 4, and 5* show the dependency of the tensile strength (*Figure 3*), of the tear propagation resistance (*Figure 4*), and the ductility (*Figure 5*) from the kiln gas dust ratio applied at the slaked lime process. Each point in the diagrams represents the statistic median of nine independent repetitions. There is only a slightly negative influence to the tensile strength, and a little more negative influence to the ductility. But there is a very strong influence to the tear propagation resistance, which seems surprising at the first sight.

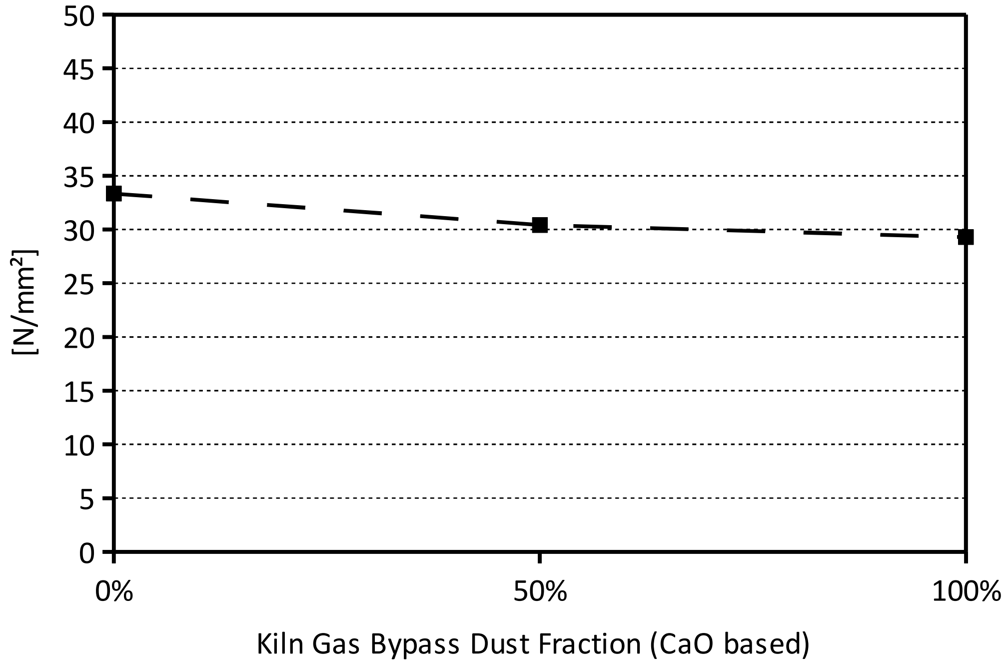

Figure 3 : Influence of the kiln gas bypass dust fraction at the slaked lime process to the Tensile Strength.

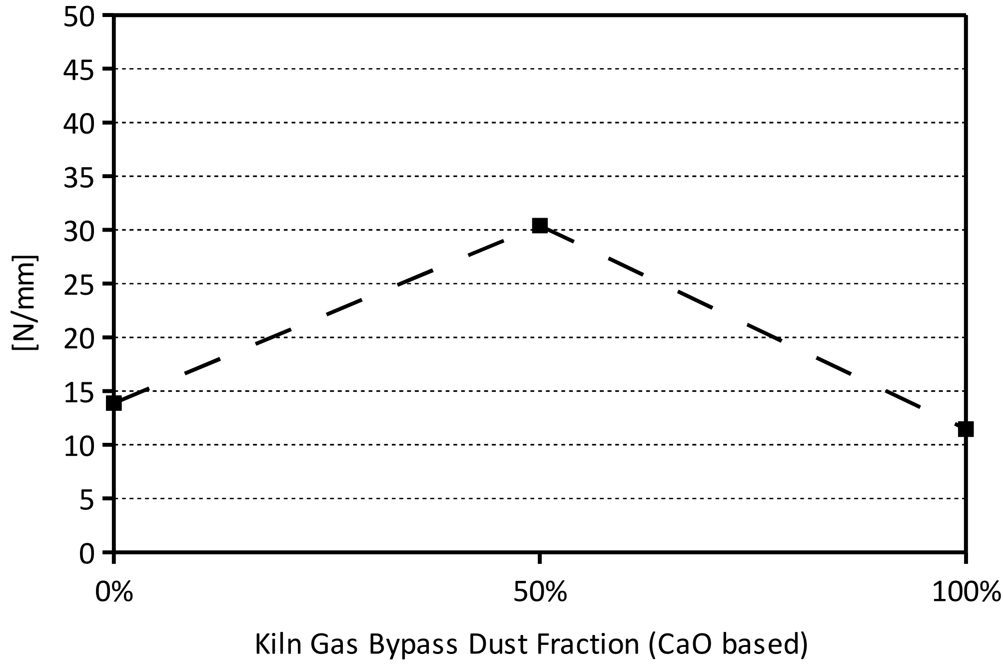

Figure 4 : Influence of the kiln gas bypass dust fraction at the slaked lime process to the Tear Propagation Resistance.

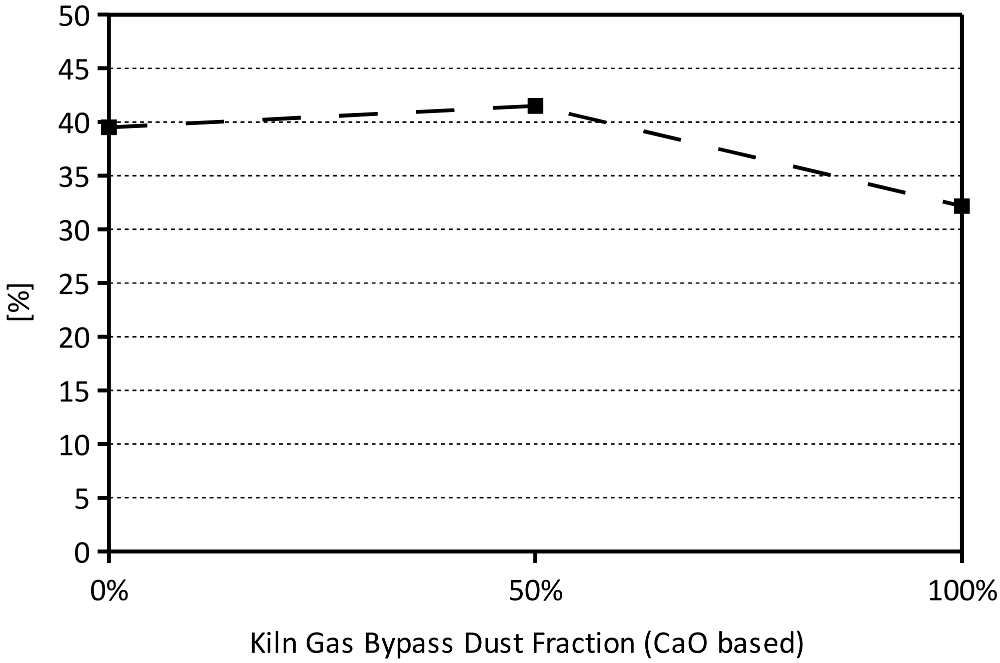

Figure 5 : Influence of the kiln gas bypass dust fraction at the slaked lime process to the Ductility.

The measurement of the water vapor permeability confirms the influence of the kiln gas bypass dust to the leather texture. The results are given at *figure 6*. Again each point in the diagram represents the statistic median of nine independent repetitions.

Additionally to these measured results a survey about the textural impression of the three leather products took place. Therefore three identically looking pieces of leather with 100 mm x 100 mm x 1 mm dimension each have been prepared. One-hundred independent probands have been asked, to share their individual impression which leather piece is the softest. *Table 2* shows the results.

Table 2 : Individual impressions on the softness of the Leather samples

Leather Sample	Individuals, who find it's the softest leather
0 % Kiln Gas Bypass Dust	11
50 % Kiln Gas Bypass Dust	27
100 % Kiln Gas Bypass Dust	62

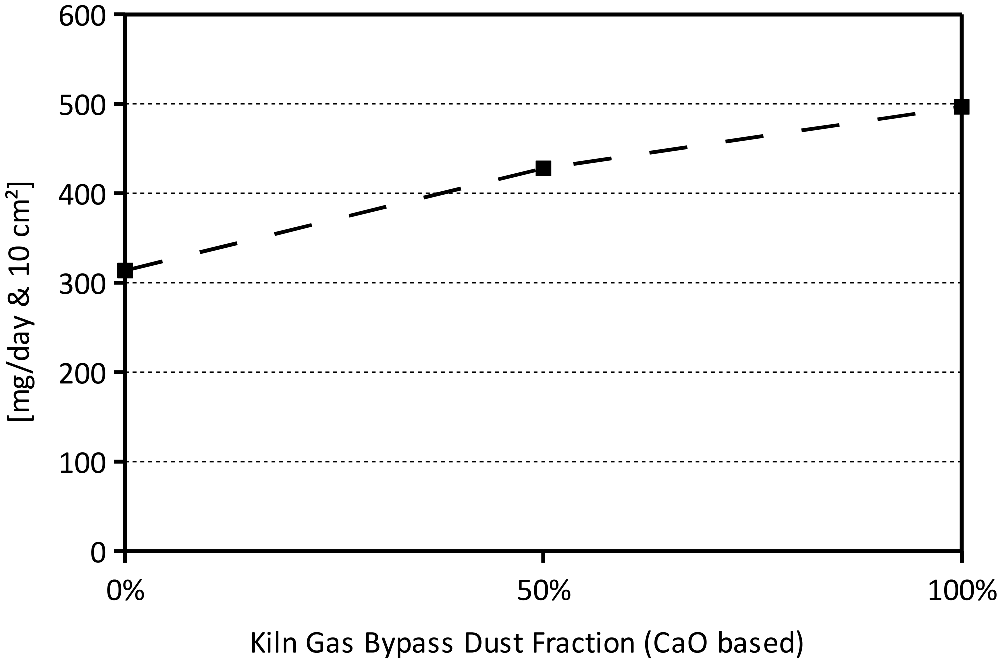

Figure 6 : Influence of the kiln gas bypass dust fraction at the slaked lime process to the Water Vapor Permeability.

Conclusion

The measurement results proofed a clear relation between the substitution ratio of the lime hydrate by kiln gas bypass dust and the final leather behavior. Regarding the chemical behavior of the kiln gas bypass dust there are only a few substances which could affect reactions with the raw skin due to there well solubility. These are lime hydrate ($Ca(OH)_2$), potassium and sodium chloride (KCl and $NaCl$), and traces of gypsum ($CaSO_4$). The balance, about 45 %, are strictly insoluble at the conditions of the slaked lime process. Looking at the salt content of the kiln gas bypass dust, the calculation of the salt concentration of the slaked lime process liquor yields approx. 1.1 % or 147 mmol/L respectively of salt expressed as KCl at 100 % substitution rate. For 50 % substitution rate there are still 0.55 % or 73.5 mmol/L respectively salt (KCl) in the liquor. These salt concentrations are enough to have an influence on the protein behavior of both, the soluble and the matrix proteins. It seems that the protein solubility has been increased significantly. Therefore the alkaline decomposition reactions are slightly more intensive as usually. This consideration fits to the results of the leather texture measurement methods at different substitution ratios. These interesting facts are now under further investigation.