INTRODUCTION

This insight presents an example of an existing industrial symbiosis between the industrial minerals industry and the pulp and paper manufacturing industry.

USE OF CALCIUM CARBONATE IN PAPER

Industrial papermaking almost always involves the use of fillers and coating minerals to improve the appearance and properties of the finished product such as brightness, opacity, gloss and printability. These fillers also decrease production costs by reducing the amount of higher cost fibrous raw material. Finally, filler and coating minerals enable production machinery to operate at higher speeds and for the finished paper to dry faster, which reduces energy consumption.

The most commonly used filler and coating minerals in paper manufacturing are ground calcium carbonate (GCC) and precipitated calcium carbonate (PCC). In turn, the paper industry is the single largest market for calcium carbonates. In 2015, the paper industry consumed an estimated 32Mt, divided between GCC (26Mt) and PCC (6Mt). The use of calcium carbonate in paper has grown steadily in the last 30 years, mainly due to technological developments that allowed for an increase in the mineral content which nowadays can exceed 50% in certain graphical papers.
PRECIPITATED CALCIUM CARBONATE (PCC)

While the vast majority of calcium carbonate is produced using the GCC process, PCC is of significant importance in the paper industry. PCC can be produced in different ways, some familiar processes being the lime-soda process and the Solvay process, in which PCC is as a by-product of ammonia production. The most frequently deployed process however is the precipitation with carbon dioxide as shown in Figure 2. Starting from a high-quality lime that is mixed with water, a calcium hydroxide solution is obtained. Through the subsequent admixture of carbon dioxide, the calcium hydroxide is converted into PCC in an exothermic reaction. Overall the following chemical reactions take place in the production of PCC:

\[
\text{CaO} + \text{H}_2\text{O} \rightarrow \text{Ca(OH)}_2 \\
( \text{Slaking, } \Delta H = +1134 \text{ kJ/kg CaO} )
\]

\[
\text{Ca(OH)}_2 + \text{CO}_2 \rightarrow \text{CaCO}_3 + \text{H}_2\text{O} \\
( \text{Precipitation, } \Delta H = +1996 \text{ kJ/kg CaO} )
\]

By adjusting the reaction conditions such as concentration, temperature, pressure, pH and chemical additives the crystal form and particle size distribution of the PCC product can be influenced, which allows for the manufacture of tailor-made particles best suited for the final product.

SYMBIOSIS WITH PAPER INDUSTRY: ON-SITE PCC

Precipitated calcium carbonate is predominantly used in the paper industry. Technological developments during the last few decades have allowed for the switch from acidic to neutral papermaking methods, leading to an increased deployment of on-site calcium carbonate plants. The total capacity of these satellite plants is around 10Mtpy, the majority of it coming from PCC (6-7Mtpy). On-site plants are located directly on the user’s site, so that the produced PCC slurry can be immediately fed into the paper production. In turn, the satellite plants usually receive energy, water and CO\(_2\) from the paper mills, as shown in Figure 3.
Compared to standalone plants, an on-site PCC facility brings several advantages regarding a more efficient use of energy and material resources. Satellite PCC plants immediately capture and absorb most of the CO₂ from the adjacent papermaking process and its auxiliary machines, turning it into an important raw material for paper production. As satellite plants are located directly at the customer’s site, no transportation of the produced calcium carbonate is required. This is especially relevant as industrial papermaking technologies allow on-site plants to feed the produced PCC directly into the paper production at very low solid contents, whereas off-site facilities first need to thicken the PCC slurry to obtain favourable transport conditions as shown in Figure 4. Furthermore, PCC plants generate a lot of low-temperature heat, as both slaking and precipitation are exothermic reactions. Off-site facilities might use part of it for space heating, but are usually not able to valorise all of the heat. Conversely, satellite PCC plants can often provide the generated heat to the partner company as an additional form of symbiosis.
CO$_2$ MINERALISATION

On-site PCC production can also be considered a good example of valuing carbon emissions through capture and reuse of CO$_2$ as raw material in process industry. In general, the mineralisation of CO$_2$ has been considered a promising technology for the sequestration of carbon emissions, allowing a CO$_2$ mitigation potential of 20-70%. It provides permanent storage for CO$_2$ without the requirement for specific storage sites, transport pipelines, or monitoring equipment to prevent leakages. In other words, the mineralisation of CO$_2$ offers permanent storage for CO$_2$ without leakage and thus provides greater public acceptance. In addition to that the produced precipitated calcium carbonate (PCC) can be valorised in process industry if it meets certain quality requirements.

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