Admixtures and sustainability

With reducing the environmental impact of cement manufacture high on the agenda for producers, sustainable cement additives based on renewable materials can contribute towards reducing a plant's carbon footprint and lowering costs.

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Modern cement producers face numerous challenges and opportunities. Amongst these, reducing their environmental footprint has rapidly topped their agenda. Cement plants have become at the same time one of the most prominent CO_2 emitters and leaders in reducing such emissions.[1,2]

GCP Applied Technologies, through its various incarnations (Dewey & Almy, 1919-1954; WR Grace, 1954-2016; GCP Applied Technologies, 2016-present day), has accompanied cement producers for almost 90 years, helping to reduce their environmental footprint with numerous inventions and practical applications.[3,4] These inventions include US Patent No US 6,048,393 and US 6,290,772, the foundation of its OPTEVA™ ESE product line, and US 8,758,504, the basis of many of its newer OPTEVA™ quality improvers.

More recently, GCP has launched two new families of additives, OPTEVA™ HE additives for high early strength cements[5] and TAVERO™ VM grinding aids for vertical roller mills.[6]

GCP has now announced the issuance of a patent addressing methods for increasing the efficiency of cement and mineral grinding by using sustainable raw materials. European Patent No EP 1 728 771 B1 has been granted and registered in 17 European countries.

GCP announces the issuance of a patent for increasing the efficiency of cement grinding by using sustainable raw materials

Sustainable chemistry

Similarly to other grinding aids and quality improvers, the new additives enable cement plants to reduce the energy consumption and CO_2 emissions associated with cement production. Additionally, these additives are based on bio-derived glycerol (eg, glycerin esterified from animal or plant fats), which involves renewable natural resources, allowing cement manufacturers reduced use of oil-derived chemicals.

Demirbas describes the production of biodiesel via transesterification, with the by-product glycerol.[7] Once biodiesel is produced from natural oils, glycerol, with higher density, settles out and can be removed from an outlet at the bottom of the kettle. The feedstock materials for the commonly-used glycol and amine grinding aid components are ethylene (ethene), based on petrochemical hydrocarbons, produced via the intermediate ethylene oxide, often via steam cracking at 750-950˚C.[8,9,10]

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As with any other technology, sustainable chemicals also have to prove their effectiveness and economic viability for use in cement production. Presented below are cost-performance analyses of new GCP sustainable cement additives drawn from industrial applications.

Case study 1

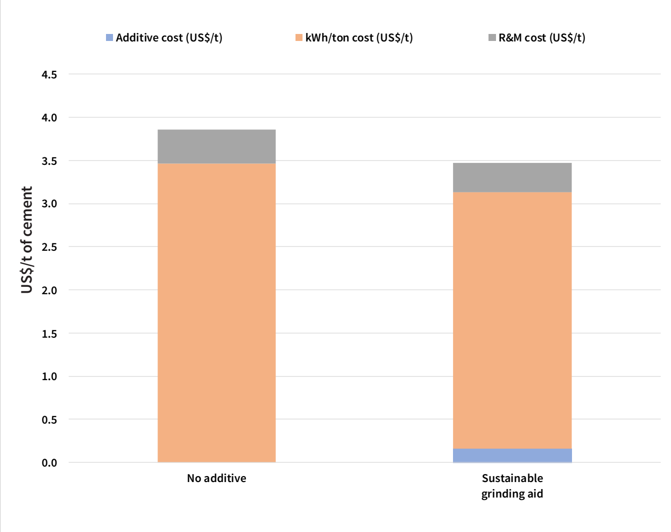
In this first case study, a formulated GCP sustainable grinding aid is used to reduce the cost and the energy required to produce a CEM II/B-M 42.5N at a 0.4Mta plant in eastern Europe (see Table 1 and Figure 1). This cement, composed of clinker (63 per cent), slag (20 per cent), limestone (12 per cent) and gypsum (five per cent), had previously been produced without a grinding aid.

Following the use of the GCP sustainable grinding aid, results showed that mill output increased by 16 per cent from 85tph to 99tph. Energy requirements were also lowered from 49.4kWh/t of cement to 42.4kWh/t. Considering 0.5kg of CO_2 is emitted per kWh used, and 13kg of CO_2 is emitted on average each day to run a car, total energy savings at this plant is

Table 1: effects of using a sustainable grinding aid

Additive	No additive	Sustainable grinding aid
Dosage (g/t)	–	400
SSA (cm²/g)	4460	4780
Residue at 45µm (%)	14.6	13.1
Strength at 2 days (MPa)	17.6	18.4
Strength at 28 days (MPa)	46.8	47.3
Mill output (tph)	85	99
Specific consumption (kWh/t)	49.4	42.4
Additive cost (US$/t of cement)	0	0.16
kWh/t cost (US$/t of cement)	3.46	2.97
R&M cost (US$/t of cement)	0.40	0.34
Annual saving – 0.4Mta	≈US$160,000	

Figure 1: savings with the use of a sustainable grinding aid



equivalent to taking over 300 cars off the road for one year. Total cost savings with the sustainable grinding aid is calculated to be US$160,000/year.

Case study 2

At a second cement plant in eastern Europe, also producing a CEM II/B-M 42.5N cement, the cost savings for the producer with the GCP sustainable grinding aid exceeds the cost savings with a standard grinding aid (see Table 2 and Figure 2). The cement composition is clinker (68 per cent), fly ash (28 per cent) and gypsum (four per cent).

The cost savings is US$0.25/t of cement with the standard grinding aid, and US$0.30/t with the sustainable grinding aid. Total energy savings at this plant, which grinds 300,000tpa of cement, is equivalent to taking over 300 cars off the road for one year with the standard grinding aid, and over 260 cars off the road for one year with the sustainable grinding aid. Total cost savings for the plant with the standard and sustainable grinding aid is US$85,000 and US$100,000, respectively.

Case study 3

At a cement plant in the US that produces 1.5Mta of CEM I, a GCP sustainable grinding aid (test) was compared to their current grinding aid (baseline). Cement was made to constant Blaine, comparing mill output and cement strength. Cement strength was tested according to ASTM C109 and reported in MPa.

With the GCP sustainable grinding aid, mill output increased from the baseline 125tph to 140tph (see Table 3 and Figure 3). Both early and late strength increased by 10 per cent. The use of the sustainable additive lowered the energy required by nine per cent from 47kWh/t of cement to 42.9kWh/t. The total energy savings at this plant is equivalent to taking over 680 cars off the road for one year. The total cost savings for the plant with the sustainable grinding aid is calculated to be US$528,000/year.

Conclusions

GCP sustainable cement additives are patented, formulated additives based on materials with a low environmental footprint, which through energy savings,

Table 2: comparing bio-derived and standard grinding aids

Additive	Blank (no additive)	Standard grinding aid	Bio-derived grinding aid
Dosage (g/t)	–	400	400
SSA (cm²/g)	≈3200		
Residue at 45µm (%)	≈1.5		
Mill output (tph)	70	85	83
Specific consumption (kWh/t)	54.3	44.7	45.8
Additive cost (US$/t of cement)	0	0.29	0.18
kWh/ton cost (US$/t of cement)	2.71	2.24	2.29
R&M cost (US$/t of cement)	0.40	0.33	0.34
Annual saving – 0.3Mta		≈US$85,000	≈US$100,000

Figure 2: GCP sustainable grinding aid exceeds costs savings from a standard grinding aid

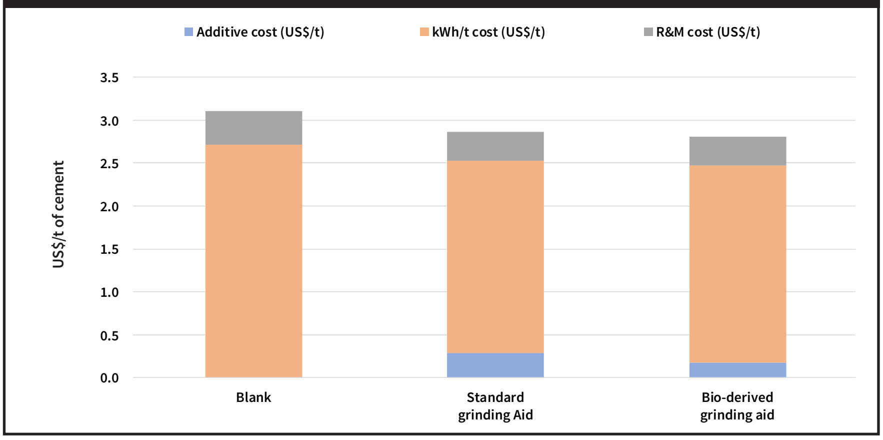
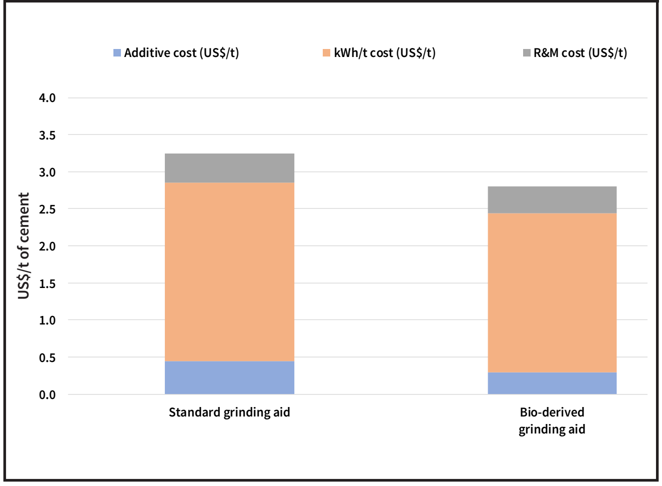


Table 3: comparing grinding aids at a US cement plant		
Additive	**Standard grinding aid**	**Bio-derived grinding aid**
Dosage (g/t)	450	290
SSA (cm²/g)	4000	4000
Strength at 1 day (MPa)	16.6	18.3
Strength at 28 days (MPa)	35.9	40.0
Mill output (tph)	125	140
Specific consumption (kWh/t)	47.2	42.9
Additive cost (US$/t of cement)	0.45	0.30
kWh/ton cost (US$/t of cement)	2.40	2.14
R&M cost (US$/t of cement)	0.40	0.36
Annual saving – 0.65Mta	≈US$528,000	

Figure 3: savings achieved at the US cement plant



reduce the carbon footprint of cement. In most cases, these additives provide cost savings for the cement producer. ■

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