Cost versus value

by Keith Marsay, Riccardo Stoppa & Mike Sumner, Grace Construction Products, UK

While simple grinding aids can create a modest net economic advantage, the use of fully-customised additives can maximise benefits and improve the efficiency of the grinding process as well as deliver a higher-quality end-product.

Following the recent financial disturbances in world markets there has been an understandable focus on the reduction of cement production costs to maintain competitiveness or simply to stay in business. Considering typical cement variable production costs, a simple conclusion to reach would be that if the plant were to stop using cement additives then the cement variable production cost could be reduced immediately by some US$0.30-1.50/te (depending on additive type). This could represent an important percentage of total variable costs. However, it also simply treats the additive as a 'cost' and takes no account of the value of the benefits the use of the additive brings to the cement and production process.

We could say that if customers consider that the use of cement additives is costing them money, then they should simply not use them. More realistically, people need to focus on the benefit they bring and that this should always outweigh the cost of the additive.

The simplest example of additive use concerns the application of a traditional grinding aid (see Figure 1). Here the objective is to increase the mill throughput thus reducing variable production costs, principally through a kWh/te saving.

In this example, the application of a grinding aid brings an improvement in mill output of just over 10 per cent, which can be translated into an annual saving of just over €32,000, mostly in electricity efficiency savings alone, over and above the treatment cost of the additive. In this case, the additive brings some value to the process, albeit of a relatively modest amount. But importantly there is no longer a cost – rather a (small) net profit.

Simplified Value Model (including cost of CO2)

Version 5.0

Mill Power	2,200	kW	Electricity	0.07	$/kWh
Ancillaries	500	kW	R&M	0.4	$/t
Total	2,700	kW	Clinker	25	$/t
Clinker tonnes	500,000		Limestone	4	$/t
			Fly Ash	10	$/t
			CO2		$/t
Currency, $ =	Euro		Clinker CO2 Factor	862	kg/t

	Reference	
	Blank	GA
Additive Cost/t	0	900
Dosage g/t	0	300
Limestone	4	4
Fly Ash	12	12
Output t/hr	65	72
kWh/t	41.5	37.5
kWh/t cost	2.91	2.63
Costs per Cement tonne		
R&M Cost/t	0.40	0.36
Composition cost/t [1]	21.11	21.11
CO2 cost/t [1]	0.00	0.00
Sum	24.42	24.10
Saving/t		0.32
Additive Cost/t	0.00	0.27
Net Saving/t		0.05
Annual Saving $		32,646
% Return		19%
Cement Volume [1]	632,911	632,911
Increase	0	0
Cement Volume [1]	632,911	632,911
CO2 Saving (t)		
CO2 Saving ($)		0

[1] Assumes 5% gypsum

Figure 1: simplified value model (including cost of CO_2)

... for the maximum benefits from the use of chemical additives, a fully customised solution is the future for successful and profitable cement additive application.

This is where the application of modern, quality-improving cement additives can bring much greater value. By acting on the clinker phases and modifying the cement strength development characteristics more cement performance can be extracted from the same clinker chemistry, enabling the addition of further supplementary cementitious materials (SCMs). As these SCMs are invariably lower cost than the clinker there is the opportunity to reduce the cement variable cost and produce more cement from the same quantity of clinker.

Let's look again at the first example, only this time applying a relatively traditional quality-improving additive (see Figure 2). In this case it is clear that by using a quality-improving additive the plant is able to add a further three per cent of fly ash. The process gain in mill output is maintained as the quality-improving additives share a similar base to the basic grinding aids. Also note that, although the treatment cost of the quality-improving additive (allowing for the additive cost and dosage applied) is somewhat more expensive (~2x) than the basic grinding aid (US$0.52/te vs US$0.27/te), the value it brings to the cost of cement is considerably higher than that for the basic grinding aid, with a net value of almost €160,000. Moreover, by replacing a further three per cent fly ash there is a potential CO_2 saving to be realised per tonne of cement and additionally, where applicable, a potential increase in cement volumes due to making more tonnes of cement/t of clinker. Although not shown here, the additional value from the CO_2 saving could be in the region of €100,000 (even with current low ETS prices).

Figure 2: simplified value model (including cost of CO_2) applying a relatively traditional quality-improving additive

Simplified Value Model (including cost of CO2)

Version 5.0

Mill Power	2,200	kW	Electricity	0.07	$/kWh
Ancillaries	500	kW	R&M	0.4	$/t
Total	2,700	kW	Clinker	25	$/t
Clinker tonnes	500,000		Limestone	4	$/t
			Fly Ash	10	$/t
			CO2 [1]		$/t
Currency, $ =	Euro		Clinker CO2 Factor	862	kg/t

	Reference			
	Blank	GA	QI	
Additive Cost/t	0	900	1300	
Dosage g/t	0	300	400	
Limestone	4	4	4	
Fly Ash	12	12	15	
Output t/hr	65	72	72	
kWh/t	41.5	37.5	37.5	
kWh/t cost	2.91	2.63	2.63	
Costs per Cement tonne				
R&M Cost/t	0.40	0.36	0.36	
Composition cost/t [1]	21.11	21.11	20.66	
CO2 cost/t [1]	0.00	0.00	0.00	
Sum	24.42	24.10	23.65	
Saving/t		0.32	0.77	
Additive Cost/t	0.00	0.27	0.52	
Net Saving/t		0.05	0.25	
Annual Saving $		32,646	159,229	
% Return		19%	48%	
Cement Volume [1]	632,911	632,911	657,895	
Increase	0	0	24,983	
Cement Volume [1]	632,911	632,911	632,911	
CO2 Saving (t)		0	0	
CO2 Saving ($)				

[1] Assumes 5% gypsum

Figure 3: simplified value model (including cost of CO_2) applying a customised quality-improving additive

Simplified Value Model (including cost of CO2)

Version 5.0

Mill Power	2,200	kW	Electricity	0.07	$/kWh
Ancillaries	500	kW	R&M	0.4	$/t
Total	2,700	kW	Clinker	25	$/t
Clinker tonnes	500,000		Limestone	4	$/t
			Fly Ash	10	$/t
			CO2 [1]		$/t
Currency, $ =	Euro		Clinker CO2 Factor	862	kg/t

	Reference			
	Blank	GA	QI	Custom
Additive Cost/t	0	900	1300	1000
Dosage g/t	0	300	400	800
Limestone	4	4	4	5
Fly Ash	12	12	15	18
Output t/hr	65	72	72	73
kWh/t	41.5	37.5	37.5	37.0
kWh/t cost	2.91	2.63	2.63	2.59
Costs per Cement tonne				
R&M Cost/t	0.40	0.36	0.36	0.36
Composition cost/t [1]	21.11	21.11	20.66	20.00
CO2 cost/t [1]	0.00	0.00	0.00	0.00
Sum	24.42	24.10	23.65	22.95
Saving/t		0.32	0.77	1.47
Additive Cost/t	0.00	0.27	0.52	0.80
Net Saving/t		0.05	0.25	0.67
Annual Saving $		32,646	159,229	425,625
% Return		19%	48%	84%
Cement Volume [1]	632,911	632,911	657,895	694,444
Increase	0	0	24,983	61,533
Cement Volume [1]	632,911	632,911	632,911	632,911
CO2 Saving (t)		0	0	0
CO2 Saving ($)				

[1] Assumes 5% gypsum

Customisation

However, customers can now discover the most profitable use of chemical additives with what Grace believes is one of the most exciting developments in additive application in recent years – customised additives (see Figure 3). The key to success here is an open and honest working relationship between the supplier and the cement manufacturer. The supplier and cement company need to thoroughly explore where there is flexibility for an additive to provide the largest value. Then define the targets for the additive as accurately as possible. Grace Customisation employs a systematic evaluation approach to solve the complexity of cement plant variables and chemical interactions. This approach uses specialised testing, statistical tools, and proprietary methodologies to identify and formulate additives for the cement plant process and material characteristics, thereby delivering maximum performance and economic benefits. The rigorous procedure matches the plant requirements against a wide range of input chemicals, many of which are patented, all of which are REACH compliant, to formulate an additive that economically outperforms the traditional additives. This may initially sound like something of a black art, however, there is a considerable degree of logic and science involved.

The cement company needs to be realistic about what its requirements are. It is very easy to simple state, for example, a requirement for extra strength at all ages with no loss in workability. However, Grace challenges the customer to define more specifically what they want and why? For example, 5MPa at two days to enable the addition of an extra five per cent SCM without loss of 28-day performance is a more specific and thus much more useful requirement.

A further requirement may be to minimise vibration on a vertical mill system to give a reduction in water consumption. This, together with the raw material and clinker analysis over as long a period of time as is possible, enables the data to be statistically analysed more accurately. For this purpose Grace uses appropriate statistical analysis tools to match the customer analysis with the wide range of chemical inputs available for additive formulation.

Combining method and experience

With a large range of input parameters there is the potential risk of simply generating a large range of outputs which could lead to an excessive number of different additives being considered. This is where the customisation methodology

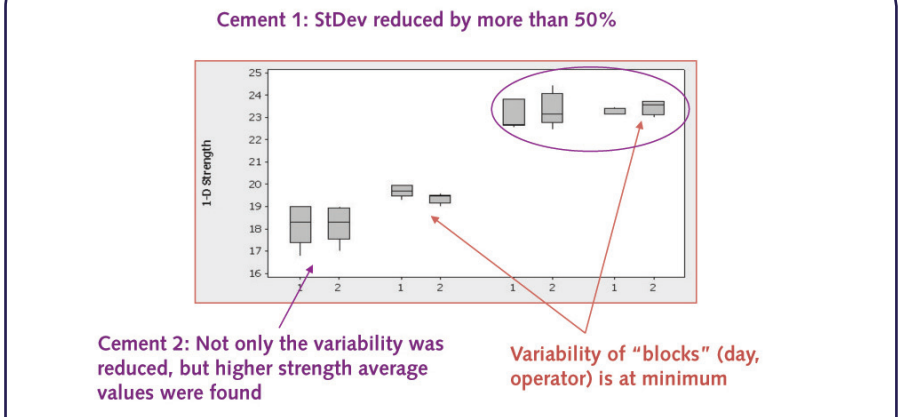

Figure 4: successful customisation requires accurate testing with low variability

is combined with Grace's established, long and wide-ranging experience.

The intimate knowledge of selecting products that work successfully with different clinker components, cement types, grinding systems and market performance is based on a global experience with a wide range of cement plants that enable the customisation process to be manageable. The process allows greater accuracy and magnitude of results by more fully exploiting synergies and combinations of chemicals to cement characteristics.

In essence the customisation process involves a pre-screening stage, followed by the main statistical formulation development and a final validation step, where cement is tested with the potential additive combinations in mortar or concrete. For the customisation to work effectively, it is critical that there is high confidence in the repeatability and accuracy of the mortar prism testing, with a lower than typical coefficient of variability. To this end, Grace has invested significant resources during the last 10 years to establish specific in-house testing methods that provide very low testing variability which is essential for a statistically sound customisation process.

Performance benefits

Successful customisation requires a dedicated focus and appropriate testing time from the request being agreed to a formulated additive being available for field trial. However, the potential performance benefits can be remarkable and thus justify the considerable effort. The cost of the resultant customised additive may often be higher than an off-the-shelf product but the value it can bring to lower the cost of cement can be significantly higher. The customisation process can also equally be applied to maintain benefits with lower-cost formulations.

In the example (see Figure 3), a customised additive at 3x the traditional grinding aid treatment cost (US$0.80/te vs US$0.27/te) providing quality enhancement that allowed a further increase in SCMs and now the 'profit' from the additive is in excess of US$425 (€400,000).

Figure 5 highlights a recent example of customisation for a cement plant of a major cement producer. The plant has a modern vertical cement mill that produces a CEM II cement with a high percentage of SCM. The requirement was defined as an increase in one-day strength tested at 10˚C of at least 5MPa and no increase in water demand for the finished cement in downstream concrete applications.

Figure 5: concrete performance of untreated cement vs cement with X1 and X2 in concrete without admixtures and with admixtures F and C

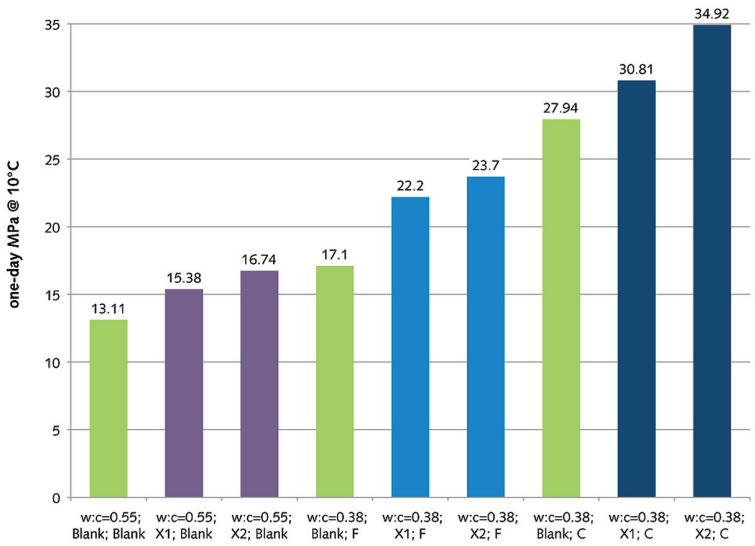

Figure 5 shows the concrete performance of the untreated cement compared to cement with additives X1 and X2 in concrete without admixture and with admixtures F and C.

With the same 0.38 concrete water demand and Admixture C there is a substantial 7MPa increase in one-day strength at 10˚C, due to the application of customised additive X2.

Conclusion

Grace continually challenges customers to regularly review the value of additives to their business. Stopping the use of additives will reduce one of the variable spends, but very rarely bring a financial saving – unless the net value of the additive had not been correctly established from the start. The cost of any additive should always be off-set by the economic value of the benefits they deliver. Simple grinding aids can usually create modest net economic benefits, while traditional quality-improving additives can demonstrate more significant economic value.

However, for the maximum benefits from the use of chemical additives, a fully-customised solution is the future for successful and profitable cement additive application. So the final say for cement additive application is 'no cost', just 'net value'.