Mineral filler solutions for cost and quality enhancement in graphic papers

Per Svending, Chris Nutbeem and Ian Elliott

PTS - 2010

PCC

GCC

KAOLIN

IMERYS
Pigments for Paper

Mineral filler solutions for cost and quality enhancement in graphic papers.

Per Svending[1], Chris Nutbeem[2] and Ian Elliott[2]

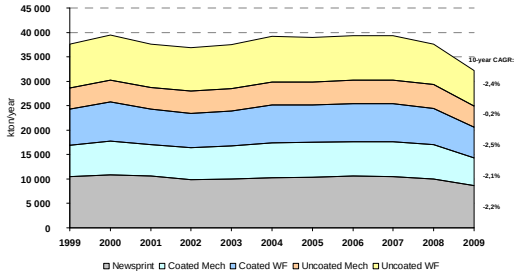
September 2010

[1] Imerys Mineral AB, Bokvägen 12, 442 31 Kungälv, Sweden
[2] Imerys Minerals Ltd, Par Moor Road, St Austell, Cornwall PL24 2SQ, UK

Paper is traditionally made from fibre and water! Only the more detail oriented papermakers may add that mineral fillers also have a slight role to play. "Chemicals", or "additives" are generally seen as a necessary evil, at best. As a pigment supplier, would like to challenge this view.

The paper market is difficult. The demand for graphic papers in Europe has been falling. The demand in 2009 was much lower than it was back in 1999. The decline in paper production has been more rapid than the closure of paper capacity.

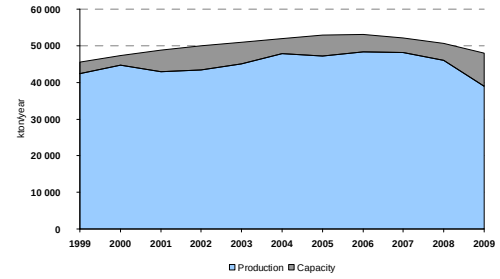
Graphic papers demand in W Europe



Graphic papers demand loss of 2% per year over 10 years

Source: RISI

Increasing graphic papers spare capacity in W Europe

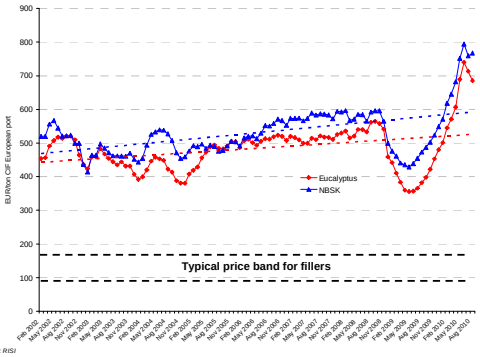


81% capacity utilisation in 2009
9 million ton capacity gap!

Source: RISI

The resulting overcapacity has meant that paper pricing is not at all following the path needed to keep up with cost increase of raw materials. Papermaker's margins are severely squeezed. The recent increase in cost of pulp is at the heart of the problem, as fibre/pulp represents the lion share of the cost in European graphic papers production.

Market pulp price in €, CIF European port



Source: RISI

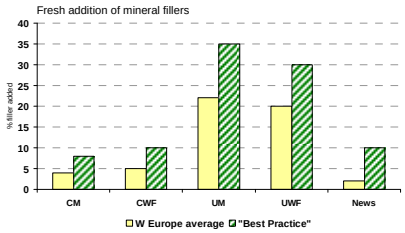
These factors are driving papermakers towards lower cost paper making approaches even if this means some compromise on quality.

Increasing the use of filler is an opportunity to achieve a well needed reduction in the cost of making paper. Given the severity of the current cost pressures, high filler concepts deserve to be looked at with renewed vigor. At today's costs there is typically an incentive of between 2 and 6 €/ton of paper to increase the filler loading by 1% unit. The average across the whole graphic papers segment is in the neighborhood of 4 €/ton of paper according to our estimate. A modest 1% unit increase would liberate some 150 M€ value across the industry. Incidentally it would also create some 10% growth in an otherwise pretty flat filler market.

When you ask papermakers what is holding the development towards higher filler loadings back they typically answer strength, PM runnability and bulk/stiffness. Historically there have been several good ideas around how to overcome the strength issue associated with increased filler use. English China Clays launched the Hylode system over 30 years ago. The Compozil system has become a well known industry standard as a retention/drainage aid, but it was originally intended to be using high addition levels of starch as a strength aid to allow high filler loadings. There have also been many other starch and/or polymer based dry strength systems introduced with quite limited success.

On the minerals side the biggest step forward was probably the introduction of PCC where the scalenohedral crystal form basically offered the UWF mills a solution to the bulk issue. The introduction of special filler pigments with engineered size distribution or shape has really had a minor impact on the market as a whole, although they have been a success in some sub-segments. All these developments have led to today's average filler use across the W European graphic papers industry of 9%. This number excludes filler coming from broke or waste based fibre but still the number is surprisingly low.

Typical filler levels in European applications



- As a region Europe tends to produce papers with higher filler content than in other geographies
- However, the filler levels in many mills remain well below the best practice in the market segment they serve.
- Strength is often the limiting factor

Source: Imerys data and Imerys perception of industrially applied best practice.

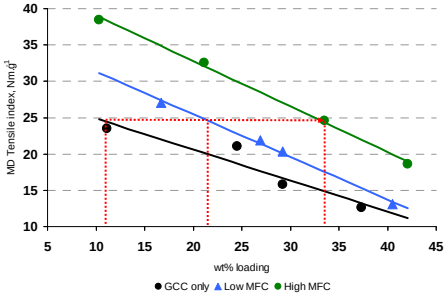
Quoting an average across the diverse sub-segments that make up graphic papers may be a bit academic. There are obviously big differences in filler use across the sub-segments. The big filler using areas are uncoated woodfree, primarily using PCC and uncoated mechanical, using mainly kaolin fillers. The SC-A grades are leading in terms of filler use. The use of platey kaolin and the dense paper structure desired allows filler loadings of 35% and more. It is worth highlighting that coated papers use only some 650 kton of fresh filler, mainly GCC, across nearly 16 million ton of paper production. Imerys has done work on coating base paper to show how the use of kaolin filler can improve loading levels and coating results. This may well be one of the areas with the greatest growth potential.

Today there is widespread hope in the industry for new products based on microfibrillated cellulose or "MFC" as it is often referred to. Primarily this is aimed at high value applications outside of paper or for paper barrier coatings etc, probably driven by a high estimated MFC manufacturing cost. Given the good strength properties inherent in MFC we have taken a keen interest in evaluating how these exciting new products could possibly be used in the much larger but relatively low value application of providing dry strength for filler increase. With hopes of a major strength improvement potential, even in the form of initial wet strength and the ability to close up the surface of the sheet MFC appears to offer technically what would be needed to make a significant difference in the paper industry's filler use.

The MFC we have evaluated is from a proprietary source but has been made available in sufficient quantity to allow evaluation on pilot paper machines *(UMIST in Manchester, UK and Eurofex of Innventia in Stockholm, Sweden).* The furnish composition used in our trials has been "woodfree", 80/20 blend of eucalyptus and NBSK. Retention aid has been a single component PAM (Percol E622). Paper basis weight was 80 gsm. The MFC has been added to the wet end blended with standard GCC filler. A practical consequence of this blending was that the MFC dose was a function of the amount of filler added.

Quite as we expected the results are technically encouraging. Adding MFC to the wet end is working without issues and it appears that the product is well retained in the paper. The addition of MFC increases the strength level to allow for significantly more filler to be used. Paper with more than 20% units increase in filler loading has been produced at constant tensile strength.

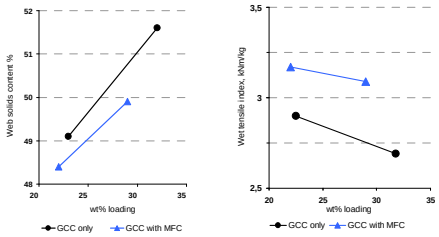
Tensile strength, geometrical mean



UMIST Manchester.

There were no runnability or formation issues associated with running even high doses of MFC although a slowing down of initial dewatering was obvious. Also paper web solids after press were reduced at equal filler loading but after filler increase to equal strength the press solids were above the reference.

Press solids and wet tensile strength

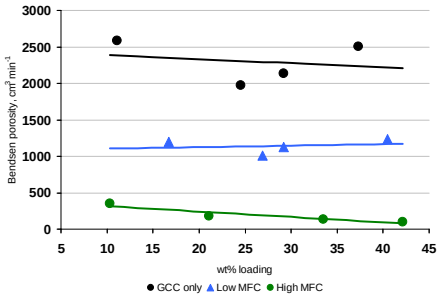


Eurofex pilot machine in Stockholm.

Given that fillers are easier to dry than cellulose it can be expected that the overall energy efficiency of drying the high loading paper with MFC would be reduced, although we have made no measurements to confirm this.

Using MFC to allow higher loading at constant strength also offers some interesting side effects on paper quality. To start with the negative, we see an increase in paper density. This effect is over and above what you would expect from the increase in filler level. Optical properties have improved, more so for opacity than for brightness, as there is an increase in light absorption coming from the MFC. At high MFC dose levels we have even seen a negative impact on brightness. Further on the positive note we see a significant reduction in porosity.

Bendtsen porosity



UMIST Manchester.

This is interesting for most paper grades, not least for coating base paper where very little filler is used today.

Two of the pilot trial paper samples were pre-calendered and used in Helicoating trials.

MFC in coating base paper, case study

- A base paper with high dose of MFC and 21% GCC filler was compared with a reference paper with 11% GCC filler and no MFC.
- The papers were pre-calendered and coated using 2 formulations
  - 100% GCC95
  - 60:40 GCC95 : Brazilian kaolin

Base Properties 80 gsm	GCC 60	GCC 60/MFC
Loading %	11	21
Tensile strength, Nm g^{-1}	32.6	49.9
Brightness F8	90.4	88.0
Opacity %	85.8	89.8
Bendtsen porosity, cm^3 min^{-1}	2558	176

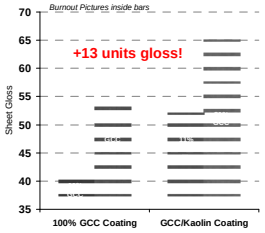
Coating Recipes	C1	C2
GCC 95	100	60
Brazilian Kaolin	-	40
SB Latex	10	10
CMC	0.3	0.3
Solids wt%	69.1	67.5
Brookfield viscosity mPa.s	1518	830

8gsm: Coatweight

Coating base paper from UMIST using a 60 grade GCC filler in a 80 g/m2 woodfree furnish (80:20 eucalyptus:pine)

The reference sample was with 11% standard GCC and the MFC paper was from our “high” dose series at 21% GCC filler loading. The results from this coating study strongly supported our hypothesis of improved coating hold out with MFC in the base paper.

Coated paper results



- Coverage at constant coat weight improved through MFC addition and increased loading in base.
- This resulted is much improved smoothness, gloss and print gloss.
- We expect that these quality benefits could be traded for significant coat weight reduction.

Filler	Loading	Coating	PPS	Gloss	Print Gloss
GCC	11	100% GCC	1.56	40	45
GCC/MFC	21	100% GCC	1.22	53	58
GCC	11	GCC/Kaolin	1.08	52	62
GCC/MFC	21	GCC/Kaolin	0.85	65	70

Coated paper gloss increased by 13 units compared to the reference and there were also significant improvements in smoothness. This indicates a potential to reduce coat weight and effectively move minerals from coating to filling, providing further savings in binders and coating additives.

Our pilot paper making results show that about 2 kg/ton of MFC is needed to allow 1% unit filler increase at equal strength. This basic effect could be used to calculate a theoretical “market value” for MFC assuming that the MFC added also replaces 2 kg or about 1 € worth of fibres. As a crude average across graphic papers the value of MFC would then be about 2,5 €/kg dry (2 kg/ton providing 5 €/ton of cost savings). So, for MFC to win general acceptance as a dry strength aid across the graphic papers segments, it needs to be priced below about 2,5 €/kg, dry delivered. How and when will this be possible?

As a bonus the MFC addition would deliver some interesting quality benefits and probably further savings potential.

Best of all, it´s not even a “chemical”! It would still be traditional paper making using fibre and water, only adding more filler and making more money.

IMERYS
Pigments for Paper

Europe
Tel: +44 1726 818000

N. America
Tel: +1 770 594 0660

Email
paper@imerys.com

Asia Pacific
Tel: +65 67 99 60 60

S. America
Tel: +55 11 2133 0055