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INCREASING THE EFFICIENCY OF USING SIZING AGENTS WITH THE HELP OF AN ACT 2500 AUTOMATED COBB TESTER FOR DYNAMIC EVALUATION OF ABSORBENCY

Sizing tests are of fundamental importance for a host of grades and applications, and as such a plethora of measurement techniques have been developed over the last century, including [1]:

1. Chemical – adding an acid or base liquid to one surface, with an indicator applied to the opposing side (e.g. Flotation, Stöckigt, Kollman and dry Indicator tests);

2. Electrical – applying electrodes to both surfaces, and following the change in conductivity or resistivity (e.g. Galvanic, Currier and Valley testers);

3. Optical – applying a dye solution to one surface and measuring changes in reflectivity of the opposing surface as the dye penetrates (e.g. BYK and Hercules Sizing testers);

4. Gravimetric – measuring the mass uptake per unit area (e.g. Cobb test);

5. Pragmatic – writing or printing with characters or images and assessing quality using optical instrumentation or visual examination (e.g. Pen & Ink Writing, Inkjet Printing);

6. Sonic Modulus – assessment of ultrasound transmission after application of a liquid (e.g. Emco DPM tester);

7. Volumetric – applying a known volume of liquid, and assessing volume uptake manually (e.g. Penescope tester).

All assess a set of related parameters, but they tend to rank papers differently, due in no small part to variations in the nature of the probe liquids used – this can be with respect to pH, ionic content, surface tension, and in some cases temperature and viscosity, all of which affect the mode by which liquids interact with cellulose fibers.

Some tests (e.g. pen & ink writing and inkjet) are more important for specific grades only and are not general tests applicable to all papers. Other tests (e.g. chemical or electrical) have fallen out of vogue, while the volumetric test was never popular and the ultrasonic method is very hard to interpret. With this in mind it is probably safe to say the most popular test throughout large swathes of the UK and European market is gravimetric assessment, most obviously typified by the well-known Cobb test (ISO 535; TAPPI T441; ASTM d3285).

Cobb Test Background

Miss R.M. Cobb was chemist in charge of the research laboratory of Lowe Paper Company, Ridgefield, N.J. She presented her seminal paper at the TAPPI AGM of 1934 [2], and her work assessed, among other features, the effect of hydrostatic pressure (the 'head' of water sitting on top of the sheet, forcing it in to the paper structure) and contact time (how long the excess water re-mains in contact with the sample prior to couching). All this led to development of some reasonably simple and cheap laboratory equipment consisting of a base upon which the paper sample is placed, a metal cylinder which is clamped on top of the sample and used to contain liquid contact to a pre-determined area; and a roller to couch the wetted sample and remove excess liquid from the sheet prior to final weighing.

The test method involves weighing a sheet of sufficient area to allow a test to be performed. After the cylinder is clamped in place, water is applied to the paper surface and simultaneously a clock is started. At a predefined time the excess liquid is re-moved and the cylinder unclamped, and at a second time-limit the sample is couched using blotters and a heavy roller. The now damp sample is then reweighed, and the liquid uptake per unit area at the time used for couching is reported. High values indicate poor sizing.

The test procedure is simple to perform and gives reasonably reproducible values, although the method is subject to experimental or operator error in a number of ways:

1. Misweighing of initial (dry) or final (wet) weight;
2. Mismeasurement of the amount of liquid applied;
3. Mistiming with respect to the duration excess water contacts the sheet, or when couching is performed;

4. Mistakes with regard to the couching procedure. (If the 'Cobb' value is a little too high, a well-known trick is to 'lean' on the roller and apply a bit more pressure to help remove excess water and so reduce the value).

Indeed, in addition to the above, Miss Cobb noted the test suffers from other disadvantages, namely:

1. Constant attention must be given to the test;

2. Manipulation requires care and reasonably good technique;

3. Tests cannot be readily applied to light absorbent stock that soaks through in less than 15 seconds.

To this could also be mentioned the most common Cobb value is obtained after the vast excess of liquid is applied to the paper surface for 45 seconds (ISO 535) or 50 seconds (T441) prior to blotting at 60 seconds; for most end uses this represents a great excess both in water volume and contact duration compared with the timescale many liquids remain on a paper surface. In particular contact time has always been a major problem: the inability to work accurately well below 30 seconds where the vast majority of important interactions between liquids and paper take place – for example during printing, gluing, ruling and similar operations – is a major disadvantage. The inability to assess what is happening in the zone of interest can easily lead to oversizing, which has obvious cost implications and is a major cause of printing errors, gluing problems, and general adhesion issues (for example with hot foil applications).

It is against this background that one instrument manufacturer – **Fibro System AB** (part of the **TMI** group of companies) – has developed an automated instrument which shows good general correlation with the Cobb test and has a number of important ad-vantages over the traditional method, namely:

1. It limits the amount of operator variability by removing many of the opportunities outlined previously where in-accuracy of even deliberate fraud can occur;

2. It produces far more accurate and consistent measurements, allowing chemical usage to be optimized and making significant financial savings possible;

With a measurement frequency of 10Hz (10 times per second) from the point of contact, it gives far more information on liquid-paper interactions that is possible with the traditional Cobb test;

3. It frees up testing staff to concentrate upon other work, as the test is entirely automated;

4. It improves safety by removing the need for sample preparation using sharp knives, and for couching the wetted sample using a heavy roller.

ACT 2500 – measurement principle

The ACT (Automated Cobb Tester) 2500 (Figure 1) is a high specification instrument for continuous measurement of liquid uptake over time. The heart of the apparatus is a porous glass plate through which water is forced by a pumping system. Above the plate sits a soft pressurized rubber diaphragm; between the two is a stage upon which the paper sample (minimum size A5) rests (Figure 2).

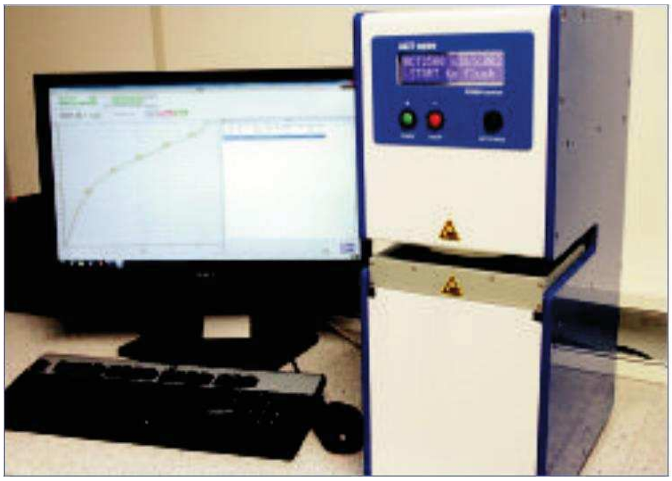

Figure 1. The ACT 2500

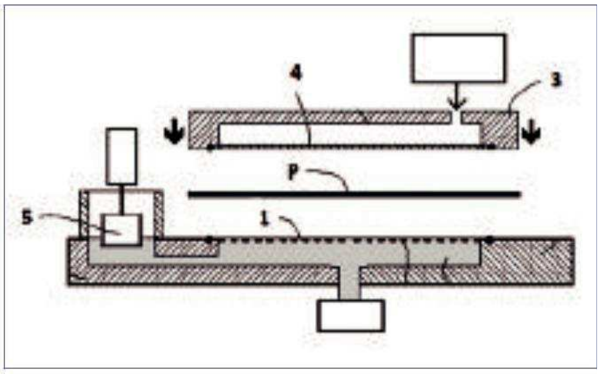

Figure 2. Graphic showing the relative positions of the porous plate [1], sample [P] and pressurised rubber diaphragm [4], along with the clamp [3] and level sensor (see below) [5]

Prior to a test, water is pumped through the plate to saturate its surface. Then the start button is pressed and the diaphragm is pressurized slightly pushing the paper sample onto the porous plate surface. The diaphragm promotes intimate contact between paper specimen and the plate; simultaneously it helps smooth out wrinkles and prevents sample distortion.

Immediately upon contact with water the paper specimen will start absorbing liquid through capillary attraction, and the volume of liquid upon the plate decreases. Attached to the plate is a liquid reservoir housing a very accurate level sensor; as liquid is depleted from the porous plate it is replenished from this second chamber, which has a cross sectional area one tenth that of the porous plate. Uptake of a 1 μm layer of water from the plate equates to 1 gsm gravimetric absorption; in the reservoir this in turn equates to a 10μm change in level. It is this level the instrument monitors at 10Hz and which is used to calculate the Cobb value, with a resolution of 1μm (equivalent to a Cobb value of 0.1gsm). On a computer screen this data is shown continuously as an ever-changing curve on which any number of data labels (or tags) can be pre-set – so it is possible, for example, to show the derived Cobb at 10, 20, 30, 40, 50 as well as 60 seconds contact as labels on the absorption curve.

All this is produced automatically without an operator needing to stand over the instrument, and after a test is completed, the instrument flushes through water to remove any fiber or filler adhering to the plate, and in approximately 30 seconds is ready for another test to commence.

Continuous measurement vs spot test

The Cobb test has always been an imperfect assessment of sizing capability. It is a pragmatic test that has become widely accepted because it is reasonably easy to perform and the equipment is cheap. However, as performed in most mills it is a single spot test – regardless of whether the contact duration is chosen as 30 seconds, 60 seconds, 2 minutes or 30 minutes, it gives a single point of data. The test duration is chosen mainly for historic reasons, and in most cases has absolutely nothing to do with any end use criteria. Furthermore the user has no information as regards the way absorption occurred to get to the Cobb value produced. For example, *Figure 3* shows three hypothetical scenarios: curve A shows an initial rapid uptake as the surface is wetted, then a delay as a barrier is breached, before further absorption occurs; curve B shows linear absorption with time (a most unlikely proposition, but one a surprising number of people anticipate); and curve C shows rapid initial absorption reaching an asymptote due to saturation – the most common scenario. It is precisely these different modes of interaction which the ACT 2500 allows to be distinguished and quantified.

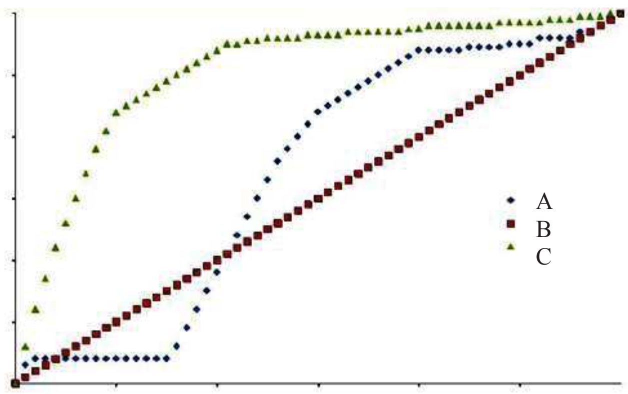

Figure 3 – Model absorption curves showing three hypothetical modes of interaction between a liquid and paper

It is a truism that if you cannot measure a property, you cannot control or manipulate it in a way that is meaningful. For example, in the case of sizing it is necessary to know exactly what protection the sizing is there to achieve: for printing it could be to control ingress of fount during lithographic printing, or liquid ink with flexography or gravure, over short time periods; but with a wrapper it may be to protect the contents of a package if caught in a rain shower. In each case the duration of contact and the amount of liquid is different, and so the type and degree of sizing requirement will change; something a single point test is not able to assess in any meaningful way, but which continuous measurement allows to be targeted.

Time and size waits for no man

A colleague at UMIST coined this title for an award-winning article some twenty five years ago [3]. The subject related to the cure time of AKD; however today with our ultra-fast machines it equally relates to a great many other properties – rapid testing and feedback of results can prevent production of copious quantities of poor quality paper.

For a typical 60 second Cobb assessment, an operator is occupied for some two or three minutes as regards sample preparation, weighing, manipulation of the apparatus, couching, reweighing, and result calculation. By contrast, the ACT allows productivity improvement by freeing operators from having to stand over the equipment, such that during the standard test method the technician simply inserts a sample and presses a button, after which he is free to concentrate upon other testing processes.

In addition, the ACT 2500 has an unusual mode for when it is imperative a result is produced very quickly. The instrument can be set to log data from numerous samples of the same grade, which it uses to produce a model of absorption characteristics. Then, when a new sample (of the same grade) is entered, it monitors the first few seconds of liquid absorption and from this calculates a predicted Cobb value at whatever set-point is required (as long as that contact duration formed part of the earlier test data used for modeling purposes). The accuracy with which this process works improves as the amount of data used to produce the model increases. This unusual procedure would allow, for in-stance, a testing department to provide extremely fast feedback to production should a problem be suspected on machine, holding the prospect of making on-the-fly changes to chemical additions much faster that would otherwise be the case – a time saving of just 1 or 2 minutes in testing could prevent production of several thousand meters of out of specification material on a modern fast machine!

Correlation with Cobb

As outlined above, the ACT 2500 does not measure Cobb directly, because Cobb is a gravimetric test and the ACT is volumetric. However, for the majority of papers TMI has found excellent correlation. Meanwhile, there is a small group of papers which do not correlate 'one-to-one' for whatever reason (one theory being the couching process 'forces' water into the structure of some open grades, artificially raising the Cobb value; another being that hygroexpansion and wrinkling of some samples gives rise to structures capable of trapping extra water, again causing an anomalously high Cobb value).

So, is the lack of a universal one-to-one correlation a problem? Given the advantages outlined previously regarding removal of operatory variability, improvement of result accuracy, the ability to analyze short-term absorption characteristics, speed of measurement and the improvement in safety, the answer is an emphatic ‘NO’. To quote Allen Bowdler of Pratt Industries:

> *This is not a recognized TAPPI test standard ... it is an in-house developed test that makes our paper and board* ***work*** *for our customers. Parallel Cobb testing using conventional manual 2 and 30 minute methods and the ACT proved to be accurate and consistent, confirming the ACT tester. Precision (reproducibility) with the ACT is superior to manual methods. The predictive feature of the ACT proved to be accurate and provides both the two minute and thirty minute Cobb values in considerably less time than the traditional method. The ACT unit has given the operations personnel prompt accurate Cobb test values that enable the operator to optimize sizing usage, reduce off spec paper production and reduce sizing costs.*

Standards have their place, but it should not be thought they are ‘universal truths’ akin to the ‘Ten Commandments’. Most will, in time, be replaced as new instrumentation becomes avail-able. For example, the manual contact angle standard (T458) was superseded by the automated test method (T558) produced, it is worth noting, by Fibro System AB – the company that has developed the ACT 2500. So Cobb was only ever a pragmatic method for giving an approximate assessment of how much size was present in a sheet, and how efficiently it was repelling water. By contrast, the advantages of the ACT 2500 in providing a rapid and accurate continuous readout of water uptake with time far outweighs any disadvantage in an apparent non-linear correlation with Cobb for some isolated grades.

Market Response

In the last couple of years, since its introduction, well over a dozen instruments have been sold to companies across the world, including: America (BASF, Pratt Industries, Sappi); Asia Pacific (Australian Paper, Minfeng, Mudanjiang Hengfeng Paper); Europe (Saica); and Scandinavia (Arctic Paper). In most cases the justification stated by paper companies is chemical cost savings; in the case of the one chemical company so far to invest it is product development.

Universally, what users have discovered is the test is much quicker to perform and inter- operator (and therefore inter-shift) variability is removed. Production gets faster feedback of more accurate data and so can make finer adjustment of chemical flows more quickly, which equates to cost savings. Furthermore the data is stored automatically so cannot be manipulated or altered, and it is possible to feed this directly into a QMS system so precluding manual transcription of information. Meanwhile, R&D

can use the instrument to derive a better understanding of exactly how quickly water is imbibed when sizing changes are made, raising the prospect of significant cost savings being possible through altering either the chemical type or amount of size (or sizing promoter) added, so allowing the correct sizing properties for the grade being manufactured to be *designed*.

Whatever the requirements, the ACT 2500 offers so many advantages over traditional sizing measurements that it is well worth investigating, especially if you are producing on high-performance fast paper machines where rapid feedback of results is imperative, or are manufacturing high value-added products where correct design of sizing performance offers commercial advantages.

The ACT 2500 is manufactured by:

Messmer Büchel

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Thanks also are due to **Test-Tech** (Paper Testing and Technology Ltd) of Amersham (PITA Corporate Members) for hosting the demonstration of the instrument.

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БУМАГА ДЛЯ ПЕЧАТИ, СОДЕРЖАЩАЯ ХЛОПКОВУЮ ЦЕЛЛЮЛОЗУ

Более 40% выпускаемой бумажной продукции составляет бумага для печати, требования к качеству которой непрерывно возрастают, особенно к бумаге специального назначения (документная, бумага для паспортов и т.д.). Это обуславливает