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THE IMPACT OF MODERN TECHNOLOGY ON PAPER TESTING

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SHOULD paper be tested in-line or off-line?

No one will argue that in-line continuous measuring of paper quality is the ultimate solution. Much progress has also been made in this direction, but we are still not there. When we do get there, we shall have to design systems for sampling, treatment and use of the in-line information before we can discard routine, off-line paper testing.

In the meantime, paper testing goes on in the routine control laboratories much as it always has. This, of course, is not necessary. When we look at routine paper testing, we ought to distinguish between the limitations inherent in the process and those that are there because of our neglect. If we do, we shall find that there is a lot more to off-line paper testing than is generally believed. If we feel a need to justify economically such a reappraisal of established methods, we can examine the cost of present paper testing. A survey in Sweden a couple of years ago showed that the operating cost of the control departments (wages, social security, testing implements) amounted to 5–6 dollars per 1 000 dollars of product. Considering that this activity has felt little impact of modern technology, it would not be unreasonable to assume substantial economic gains from a more up-to-date technique.

Still, the most valid impetus to change lies in a growing quality consciousness among users of paper.

Here, it will be claimed that paper quality expectations—provided they are reasonably realistic—can be met with the help of properly conducted off-line routine paper testing, in spite of the fact that such testing today appears to us to have very serious limitations.

Let us discuss these limitations one by one. Sampling is the worst limitation, since it is inherent in the process that samples can be taken only at reel change. (For practical purposes, there is no limit to the size of the samples.) There is nothing one can do about this fact, except observe that with increasing machine speed the time to build one set decreases. On high speed machines, it is often

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impracticable to test every set. The remaining disadvantage is that one has no control of what has happened while the set was being built. Fluctuations of shorter duration than this time, say, 30 min, must be studied by other means.

Time between sampling and testing is another limitation. This one can be practically eliminated by a tube carrier system. Such systems are also in frequent use in the paper industry for this purpose.

One of the great advantages of off-line testing over in-line testing is that it can be done in a controlled atmosphere on a sample of constant humidity.

Recent studies of through-drying have demonstrated to us how liberal we have been in allotting time for this conditioning. There is no physical reason for this conditioning to take more than a few minutes. These minutes are a small price to pay for the increased accuracy of testing.[1]

Preparing testing specimens from the samples is now a tedious, inaccurate and expensive process. This is certainly not necessary.

Two approaches are possible. One is to mechanise the specimen cutting; the other is to eliminate it. Automatic specimen cutting is to papermakers a well-known technique, which should offer no technical difficulties.

So far, laboratory technicians have appeared cheaper than machines for this job, but then the value of a short time lag has not been considered. If we put a realistic price on this, the comparison will look quite different. Specimens are not always necessary, however, if we design the testing apparatus properly. Bursting strength, smoothness, air permeability, gloss, caliper, stiffness and certainly many other tests, now made on specimens, even today can be carried out on cross-machine strips of paper, which are automatically stopped through the testing areas in the desired number of distinct steps. Unfortunately, tensile strength, folding number and tearing strength are not easily tested by this approach. We can then consider whether these latter tests cannot be replaced by others easier to automate like burst, formation, air permeability, caliper, coefficient of friction and modulus of elasticity. A correlation study on sack paper by Gavelin & Jackson showed considerable promise in this respect.[2] It is probable, however, that some machine data must also be used in the models fully to describe the paper quality, for example, efflux ratio, machine draw and cross-machine shrinkage.[3]

The implication is that, if we want really to attack the routine testing problem, we should start with a study of the requirements caused by the purposed use of the products. We should then select a set of tests, which together adequately describe the paper qualities required, at the same time lending themselves to automated testing. Quality specifications should cover not only the tested properties, but also dimensions of models calculated from the test data—that is, the acceptability of a given test value will depend on the simultaneous test values for other properties.

Assume that by such means we have been able to eliminate all tests, except those carried out automatically on cross-machine samples.

At the end of a reel, a number of cross-machine samples are cut out and dispatched by carrier tube to the laboratory. There, they are conditioned by simultaneous blowing of conditioned air on to them and sucking of such air through them. Finally, the strips are fed one into each testing station. The signals from the testing stations go into a computer, which has been suitably programmed and a report is typed out automatically at one or several locations. Punched tapes are produced for later statistical evaluation of the data.

In these processes, the human factor has been eliminated at the same time, as exact calibration has been made possible. The accuracy of the testing should therefore easily surpass that of in-line paper testing.

The time required for testing of cross-machine samples depends on the number of tests one wants to make, but 5 min should be ample.

The total time lag between sampling and report typing should then be in the range of 20–30 min. This time lag and the end-of-the reel sampling are the two inherent limitations of off-line paper testing. Against those we should weigh the advantages—

1. A conditioned sample is tested.
2. The results are inherently 'sampled' and are easy to treat statistically.
3. All tests are carried out on the same sample, therefore correlations between them become more distinct.
4. Samples can be kept for reference and later checks.
5. Enough testing can be done to yield cross-machine averages with satisfactory precision.
6. The variability within the sample with respect to different qualities is obtained as a by-product of the data processing.

In the outer control loop between papermaker and paper user, a 30 min time lag is insignificant and testing of distinct samples is the obvious solution to quality reporting, quality supervision, paper rejection and analysis of customer complaints.

In the inner control loop between papermachine and papermaker, the usefulness of off-line testing is more limited, but it will also be of value in certain areas, as described later on.

The automated routine testing described above is today a physical reality. The first installation (called Auto-line) has been in operation in a papermill since autumn 1968 and a second installation is starting up in a couple of months.

The two installations are quite different. In one case, many paper grades and basis weights are made and it was therefore found practical to present

the test results as typewritten reports on a standard form, one report for each reel tested. The reports are then sorted according to grade, basis weight and customer. In the other case, just one grade of paper is being produced. One can therefore let the computer go right on to study the trends. After each test, an automatic plotter will add the new result as a dot to a curve of previous dots on a graph. When cross-machine profiles are of interest, a plotter can be used to draw up these profiles one below the other on XY-recorders.

Clearly, these two approaches do not exhaust the possibilities of variation and the third installation will be quite different again because of local conditions and preferences.

Rather than describing these two systems, therefore, we shall try to describe the general usefulness of results from Auto-line testing.

Process control

FOR process control, plotted graphs are no doubt superior to typed reports. Digital XY-plotters, driven by stepping motors, make it feasible to record separately each important paper characteristic. Several alternatives are possible—for example, mean values, running average, deviation from specification. Visual or acoustic warning devices can be set off when specifications are not met.

Since the results become available with much shorter time lag than in conventioned off-line testing and with higher accuracy and higher testing frequency, they can be used as guides in process control to an extent that is impossible with off-line testing today, but some deliberate planning will be required to take advantage of this possibility. New routines must be developed for converting test results into corrective action. Some of these routines will involve set point adjustments, changes of specifications for operating variables and changes of furnish and additions used.

Quality control

WHEN the problem is whether paper should be sold, down-graded or sent to the broke pulpers, what counts in testing is accuracy. With the Auto-line system, it becomes possible without increase of personal or laboratory facilities substantially to increase the volume of testing. This will reduce both the risk of substandard paper not being tested and of good paper being rejected for lack of testing. The elimination of human errors in reading the instruments, plotting the results and calculating the averages will mean above all a higher reliability.

A routine of feeding a standard paper through the Auto-line at regular intervals is all that is needed to maintain assurance that the test results are correct.

This means that, when an Auto-line system is started up, one should re-evaluate the combined risks of selling poor paper and of scrapping good paper and institute new control limits accordingly. Probably, one will find that the control limits can be lowered with impunity. The combined savings of this and of less rejection of good paper by mistake can be appreciable.

Reclamations

IF A manufacturer adopts the Auto-line system, this will not affect the reliability of customer testing. If a certain shipment is in doubt, however, customers are prone to put more faith in the neat computer-typed Auto-line reports than in their own test results. This is rightly so. With an Auto-line system, not only are the result more accurate, but it is also very unlikely that anyone would influence the results with or without intent, for example, by repeating an off-standard test. If reclamations drop off significantly after the installation of an Auto-line system, this should not be surprising.

Statistics

MUCH of the value of off-machine testing is lost, if the test results are not treated statistically. Still, it is seldom possible to do this. It just takes too much time. With an Auto-line system, all test results are stored on punched tape or in the memory of the computer. At the end of a run, at regular intervals of a week or a month, reports are typed out showing average test results. Such reports are preferably programmed so that the operators, the laboratory and management each will get only the data of particular interest to them.

For each grade of paper and each customer, one can maintain a concise account of previous quality levels, against which the new shipment can be judged. Long-range trends in quality levels can be detected and reported.

Process studies

FOR process studies, in-line testing is the usual approach. There are, however, cases for which the Auto-line system offers new possibilities, thanks to high testing frequency and high accuracy. This is particularly so when the effects studies are small and easily obscured by other variables or by random variations. Examples are cyclic variations caused by seasonal variations in temperature, water quality or wood supply. Besides, the effects of changes in pulpmill or beater room or in use of chemicals may be easier to pinpoint by statistical evaluation of Auto-line results than by in-line testing. One statistical approach possible is that of running averages.

Finally, perhaps a few words should be said about the hardware for automated routine testing.

The programmed strip feeder obviously does not call for any new or unknown design. It is strictly routine to an accomplished designer of testing equipment. The testing instruments have to be modified for electric output and automatic zeroing. This has been done for a line of standard instruments and it was found to involve surprisingly little expense.

The converting, storing and treatment of the output signals brings us right into the realm of the computer specialists, where the new assignment of doing something with the output signals from the testing instruments is a trivial exercise. It is remarkable that so far only two papermills have taken what we believe is the only sensible approach to routine paper testing.

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Discussion

Mr H. B. Carter I would like to ask—in case Mr Gavelin has not already explained it—if he is suggesting that off-line testing is a suitable method for routine control? Surely, he is not suggesting that off-line testing is a suitable alternative for the controls that have been suggested earlier today.

Mr G. Gavelin When it comes to seasonal fluctuations—for example, those occurring once a year from variations in water quality or wood quality—off-line paper testing is the only means we have of finding out exactly what it does. This is just one example. One can find others. The two systems have to be used hand in hand.