A QUICK MATURITY TEST FROM THE MODIFIED IIC-SHIRLEY FINENESS & MATURITY TESTER

S. Allan Heap
International Institute for Cotton, Technical Research Division,
Kingston Road, Didsbury, Manchester, Uk

The rapid and accurate measurement of the fineness and the maturity of raw cotton is growing in importance because of additional demands which are being made on the raw material by new technology and higher productivity in the spinning industry. In this context, the Micronaire test, which has provided long and invaluable service as an approximate indicator for fineness, is no longer always adequate. After a thorough review of all commercially available test methods for maturity, the ITMF committee on cotton testing methods has recommended the IIC-Shirley Fineness & Maturity Tester (FMT) for industrial measurement of maturity as it is both the fastest and the most reliable procedure presently available.

Even so, determination of maturity and fineness using the present IIC-Shirley machine demands up to 10 minutes per bale sample and there is a strong demand that this testing time should be reduced by at least an order of magnitude in order that it should be made compatible with the so-called high-volume instrument (HVI) test procedures.

Potential for reducing testing time
The test comprises three main operations:

- sample preparation,
- specimen weighing,
- specimen loading and measurement.

Specimen Preparation
In order to obtain accurate and reproducible results, it is essential to prepare a thoroughly opened and randomised sample. At present this is achieved by using a miniature card or a Shirley Analyser or an SDL Fibreblender. The fastest of these is the SDL Fibreblender which can prepare a 10-gram sample in about one minute. By uprating the power of this equipment and by including a few changes in design, it has proved to be possible to cut the preparation time by more than one half.

Specimen Weighing
For the current FMT test it is necessary to weigh each specimen to exactly 4.00 grams. This is a rather time-consuming process and requires close and continuous concentration by the operator. Practical experience over the years has shown that incorrect weighing is probably the single most important source of variation in the FMT test. However, it has also been demonstrated that a moderately experienced operator can select a specimen whose weight lies quite close to four grams very rapidly. Therefore, elimination of the need to provide a specimen of exactly 4.00g can save several minutes per measurement. Of course, the need for precise knowledge of the specimen weight still remains but this is easily allowed for by using a modern precision electronic balance with output direct to a computer. Also, of course, the use of a specimen weight other than four

grams presupposes the existence of software capable of dealing with such specimens and I will deal with this point later.

Specimen Loading and Measurement

The measurement procedure involves insertion of the specimen into the testing chamber followed by manual selection of the two testing conditions in turn. The actual measurement in each condition is rather rapid - only a few seconds are needed to allow airflow and pressure to stabilise. After the two pressure drops have been recorded the specimen is normally removed, re-opened by hand, re-inserted into the test chamber, and re-measured. To reduce specimen loading time, a set of separate capsules can be provided. A specimen can be rather quickly inserted into one of these capsules which then needs only to be placed on a feed device from which it will be loaded into the test instrument automatically. Manipulation of the instrument's controls can be completely eliminated so that the whole testing cycle can be performed automatically.

Inspection of the variability in the measurement on individual specimens shows that the removal, re-insertion, and remeasurement of a given specimen can be eliminated without significant loss in accuracy. Once the restriction of providing a fixed weight is removed, it is much faster to make single measurements on three specimens (if required) than to make duplicate measurement on each of two specimens.

Background research

The original calibration of the IIC-Shirley Fineness & Maturity Tester rests on the provision of specimens whose weight is exactly 4.00g. The pressure drop at constant airflow is rather sensitive to the density of the specimen in the test chamber. Therefore, in order to develop the appropriate correction equations to allow variable-weight specimens to be used, it has been necessary to carry out a programme of research to establish precisely the influence of the specimen weight upon the pressure readings.

To this end a series of 20 different cottons has been collected - including the full set of International Calibration Cotton Standards - which have a fairly wide range of standard fineness and maturity. For each of these cottons numerous measurements have been made both with a fixed specimen weight of 4.00g and also with specimen weights which ranged at random between 3.5 and 4.5g.

Figure 1 shows a typical series of results for a rather mature cotton.
Figure 2 shows a typical series of results for an immature cotton.

Basic airflow theory

Neelakantan and Radhakrishnan have shown that, from the basic airflow equations presented in 1955 by Lord, the following relationship can be derived:

$$1/P = K \,.\, MHv^2 \,.\, f(x)$$

where:

P is the pressure drop, at a given airflow,
K is an instrument constant,
M is the fibre maturity ratio,

H is the fibre fineness,
v is the fibre specific volume,
f(x) is an empirical function, derived by Lord, involving the specimen weight, the test chamber volume, and the fibre specific volume.

By assuming a value for the average fibre specific volume, the function:

$$MHv^2 \,.\, f(x)$$

can be evaluated for the specimen weights actually used and a plot of these values against 1/P should produce a straight line through the origin with a slope equal to K, the instrument constant.

Figures 3 and 4 show that such plots do in fact generate nice straight lines with very high correlation coefficients. However, if their slopes are made to be constant, then they do not pass through the origin. Alternatively, if they are made to pass through the origin then their slopes are significantly different. Neelakantan and Radhakrishnan have speculated on the reasons for the lack of exact agreement between the theory and the experimental results but the practical consequence is very important. It is that, when using a single-compression test instrument, it is fundamentally not possible to derive a simple correction equation for the specimen weight which will be equally valid for all cotton types. If the cotton in question is one of average fineness and maturity then estimates based on an average instrument constant will be rather accurate but for cottons which are very fine, or very coarse, or very mature, or immature, then considerable bias can be introduced and the results become rather unreliable.

Fortunately, in the case of the FMT instrument, for each specimen we always have two values of the pressure drop (PL and PH), at different levels of airflow and specimen compression. Therefore, it has proved to be possible to construct a set of correction equations which deduce and make allowance for the offset from theoretical behaviour in a given cotton. Using these equations, the values of PL and PH which would have been found for a specimen weight of exactly four grams can be calculated from the values which are actually found using some other specimen weight. On the experimental series of 20 cottons it was found that the coefficients of variation for the estimates of PL and PH were practically the same as those obtained using the standard procedure with a fixed specimen weight of exactly four grams.

Further development and evaluation work will be needed over the next few months - in particular we would like to extend our variable weight measurements to an even wider range of cottons - but it is already clear that both the basic hardware and the software are now available which will allow the speed of fineness and maturity testing to be increased by an order of magnitude.

References

P. Neelakantan & T. Radhakrishnan: *Proceedings of the 19th International Cotton Conference*, Bremen, 1988.
E. Lord, *J. Text. Inst.*, 1955, **46**, T191.

VARIATION IN PL, PH WITH SPECIMEN WEIGHT

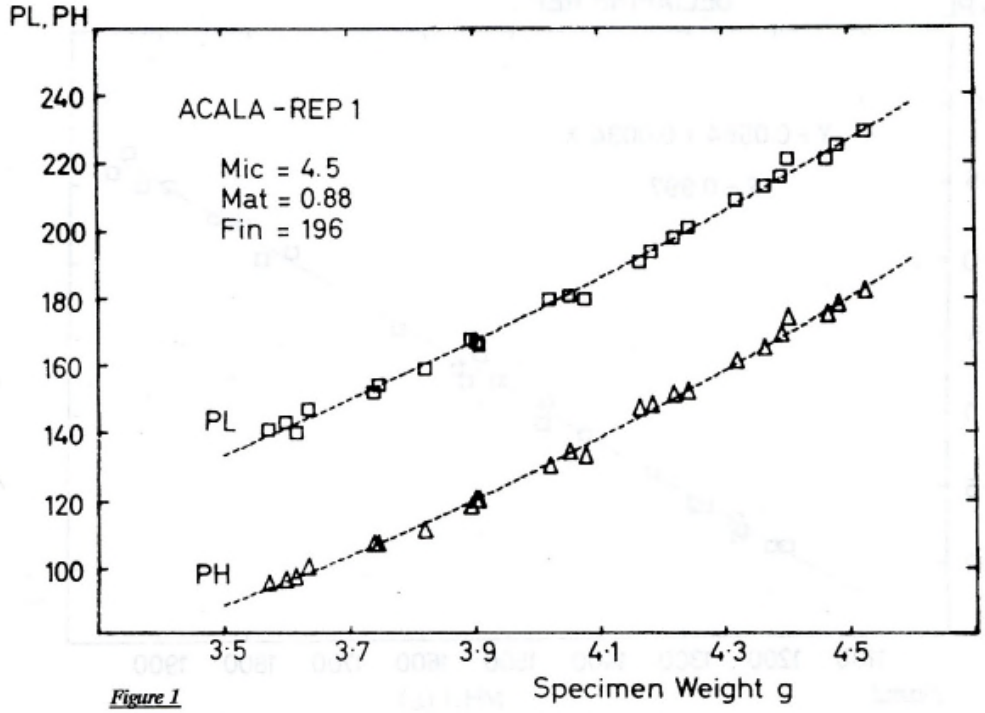

Figure 1

VARIATION IN PL.PH WITH SPECIMEN WEIGHT

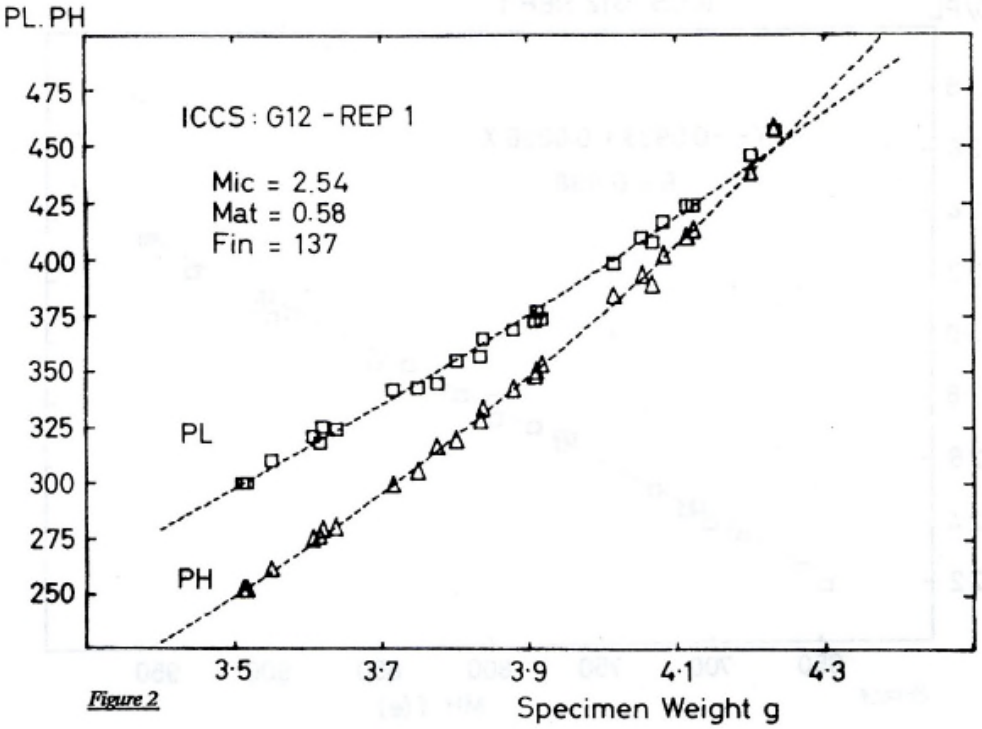

Figure 2

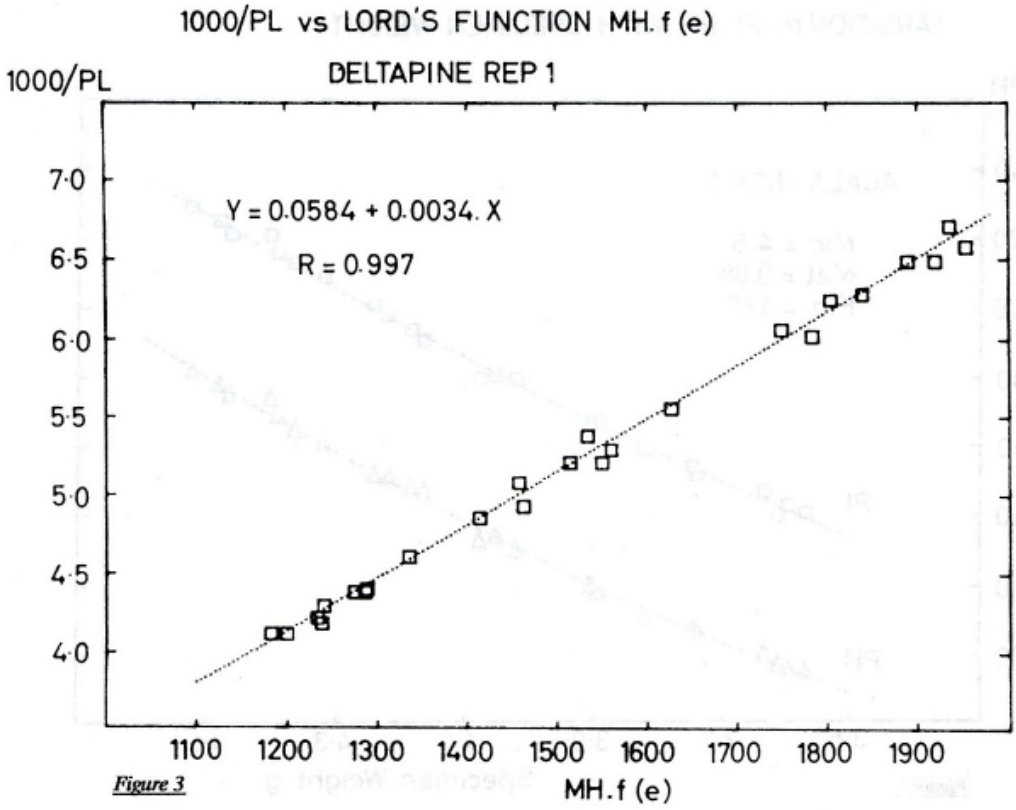

Figure 3

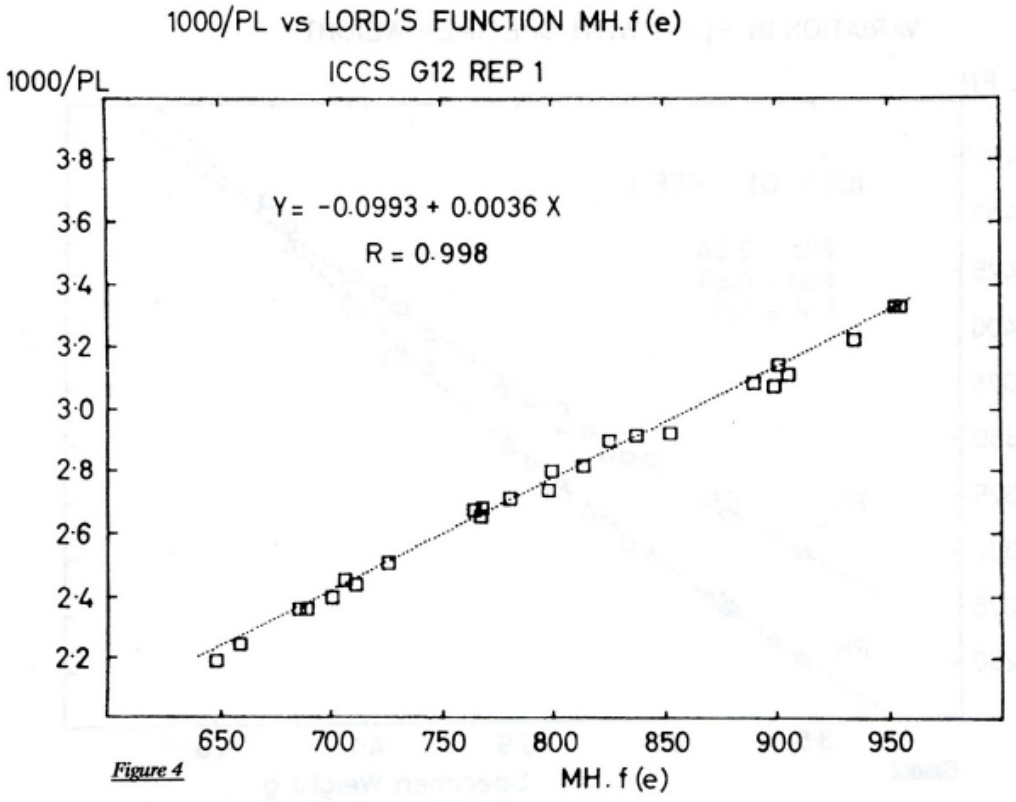

Figure 4