Note on Methods of Recording Dough Development Curves from Electronic Recording Mixers[1]

P. W. VOISEY and M. KLOEK, Engineering and Statistical Research Institute, Research Branch, Agriculture Canada. Ottawa, Ontario K1A 0C6

Cereal Chem. 57(6):442–444

Recording mixers can be designed to electronically record the mixing torque, using strain gage transducers. Several such instruments have been described: the Mixograph (Voisey et al 1966a), the Farinograph (Voisey et al 1966c, 1971), the Hobart mixer (Voisey et al 1970) and the Grain Research Laboratory mixer (Voisey and Kilborn 1974). The Amylograph (Voisey et al 1977) and the Brabender extruder (Timbers et al 1976) can be similarly modified. Different electronic recording methods can be used (Voisey and Miller 1970; Voisey et al 1966b, 1967) to obtain digital or analogue records of the mixing torque or its integrated value (energy). Compared to a mechanical recording apparatus, the electronic equipment gives more precise readings and facilitates accurate calibration (Voisey 1971).

Two measurements are widely used in interpreting dough development curves, 1) the mean torque during mixing or at some specific point (eg, the maximum) and 2) the width of the curve (Zalik and Ostafichuk 1960). Curve width is the result of the rapid torque fluctuations caused by the mixer action and is the difference between the maximum and minimum torque at a selected point in the mixing cycle. To record curve width precisely, a recorder with a rapid response (Voisey 1971) is required. Such response is not possible with a mechanical recording device and requires the use of expensive electronic recorders. Reading the average torque from an analogue record requires judgement in selecting the value within the fluctuating readings.

Electronic equipment now available permits the direct recording of the mean torque and the curve width, eliminating the limitations of recorder response and human judgement in curve interpretation. Also, the cost of electronic integrators has decreased (about 75%) since they were suggested for recording mixing energy (Voisey et al 1967). This article describes an experiment demonstrating this equipment.

MATERIALS AND METHODS

The demonstration used the 10-g Ottawa electronic recording mixer (Voisey et al 1966a). Soft and hard flours and a 50:50 blend of the two were used as test samples.

The Mixograph strain gage transducer (Fig. 1) was connected to the strain gage module of a modular data conditioning system. The modular construction permitted individual functions to be included in the apparatus as required. The strain gage module output was connected to a laboratory strip-chart recorder with a full-scale response time of 0.7 sec. This provided an analogue record of mixing torque with the curve width limited by the recorder response. The output was also connected to a digital integrator to obtain digital readings of the mixing energy used in each 10 sec and the total accumulated (Voisey et al 1967). A digital plotter could be connected to the integrator but was not available; therefore, the readings were plotted manually. The output was also connected to a maximum/minimum module to detect the difference between the maximum and minimum torque or curve width. The output from the maximum/minimum module was connected to a strip chart recorder. The maximum/minimum

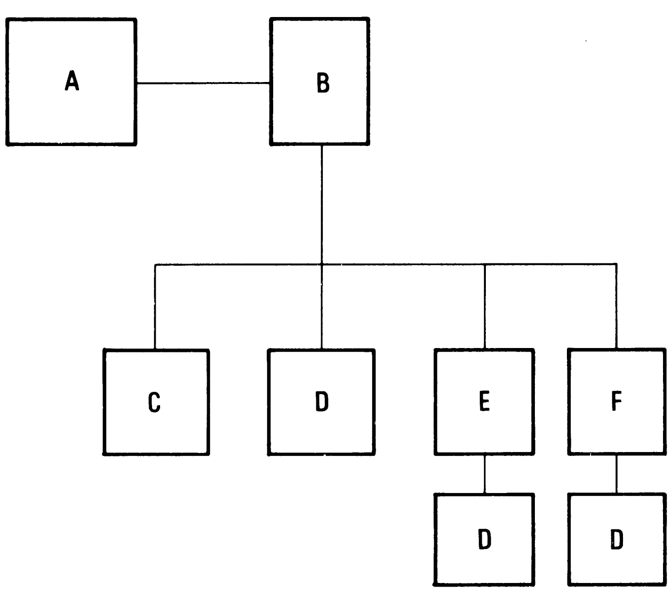

Fig. 1. Schematic diagram of the demonstration apparatus. **A,** 10-g electronic recording mixer (Voisey et al 1966a); **B,** strain gage conditioning module (Catalog No. 9270, Daytronic Inc., Dayton, OH); **C,** digital integrator (Minigrator, Spectra-Physics Inc., Santa Clara, CA); **D,** Potentiometer-type laboratory strip chart recorder, 0.7-sec full-scale response time; **E,** maximum/minimum module (Catalog No. 9279, Daytronic Inc.); **F,** ripple module (Catalog No. 9269, Daytronic Inc.).

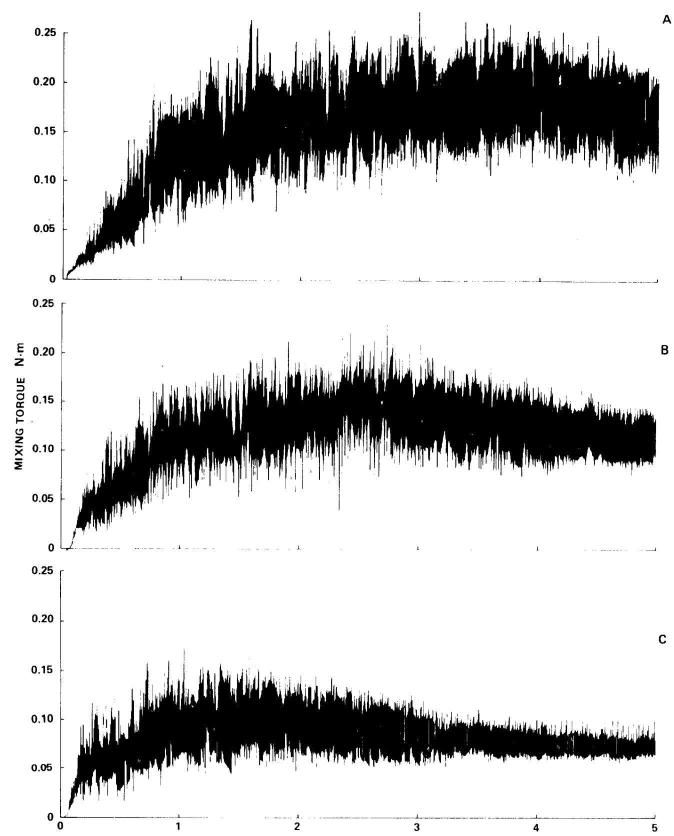

Fig. 2. Typical analogue records of mixing torque from the strip-chart recorder. **A,** hard flour; **B,** 50:50 hard/soft flour mixture; **C,** soft flour.

[1]Contribution I-187 of the Engineering and Statistical Research Institute.

module could be programmed to automatically update the curve width with any width changes until the maximum was reached. The subsequent reading then remained constant. Alternatively, a continuous record of curve width changes could be obtained by resetting the module every 10 sec by a timer. The strain gage conditioner output was also connected to a ripple module whose output was recorded on a strip chart. The ripple module recorded mean torque. Its output was the median of the input produced by dividing the deviations about the mean by one half.

The above arrangements provided a means of recording mixing torque, curve width, mixing energy, and average mixing torque. Normally not all the equipment is required, but the described arrangement permitted each recording method to be demonstrated. Other modules can be added, for example: 1) a digital readout to display or record and plot readings from the modules, 2) a peak hold module to record the maximum of any reading (eg, maximum average torque or "peak height"), and c) limit controls so that the output from any module could operate control mechanisms whenever the readings reached preselected limits. Although separate strip-chart recorders are shown connected to the modules, these could be replaced by a multipen recorder to display the readings on a single chart.

The recorders, signal conditioning modules, and integrators were calibrated by applying torque to the strain gage transducer, using weights as previously described (Voisey et al 1966a).

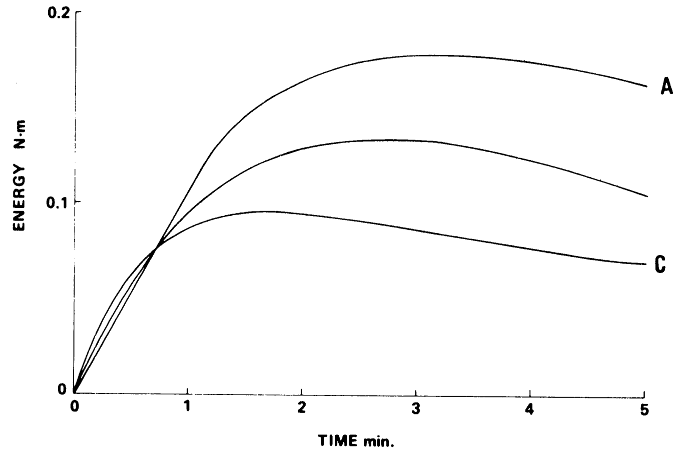

Fig. 3. Typical plots of integrator readings at 10-sec intervals of energy used in mixing. **A** = hard flour, **B** = 50:50 hard/soft flour mixture, **C** = soft flour.

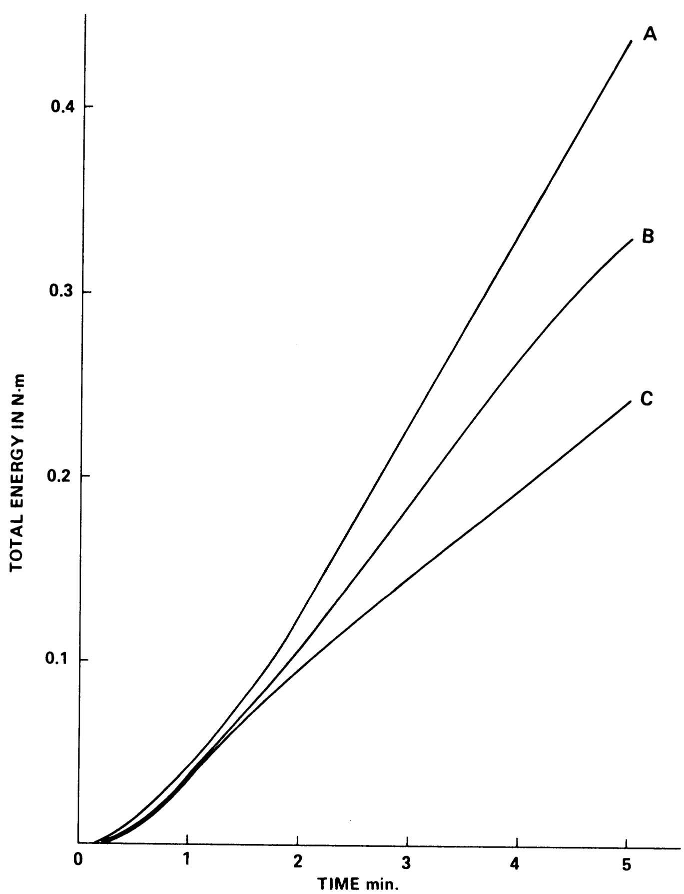

Fig. 4. Typical plots of integrator readings at 10-sec intervals of total energy used in mixing. **A** = hard flour, **B** = 50:50 hard/soft flour mixture, **C** = soft flour.

RESULTS AND DISCUSSION

Typical analogue torque records for the three flours (Fig. 2) demonstrate the difficulty of judging the mean torque, peak height, and arrival time. Plots of the integrator readings of the rate of energy use (Fig. 3) and the total energy used (Fig. 4) during mixing indicate the advantages of using digital integration for recording mixing curves. Voisey and Miller (1970) previously compared the results obtained from electronic integration and readings taken from development curves and found a high degree of correlation between them.

Curve width from the maximum/minimum module can be quickly determined from the records of either the width (Fig. 5A) or width changes (Fig. 5B). The latter shows how the curve width increases to a maximum and then decreases with mixing time. Figure 6 compares the curve width recorded by the maximum/minimum module (Fig. 5), which is unaffected by recorder response, and readings taken from the analogue records (Fig. 2), which are affected by recorder response and shows how the analogue records underestimate the curve width. The differences, at the peak height, were 205, 232, and 167% for the hard flour, 50:50 mixture, and soft flour, respectively. This supports the previous contention that analogue methods of recording curve width are inaccurate (Voisey 1971).

The ripple module produced clear analogue records of the mean torque during mixing (Fig. 7). Discrimination of fluctuations in the mean could be varied by changing the setting of the electronic filters on the module (Fig. 7A and B). The result shown for soft flour

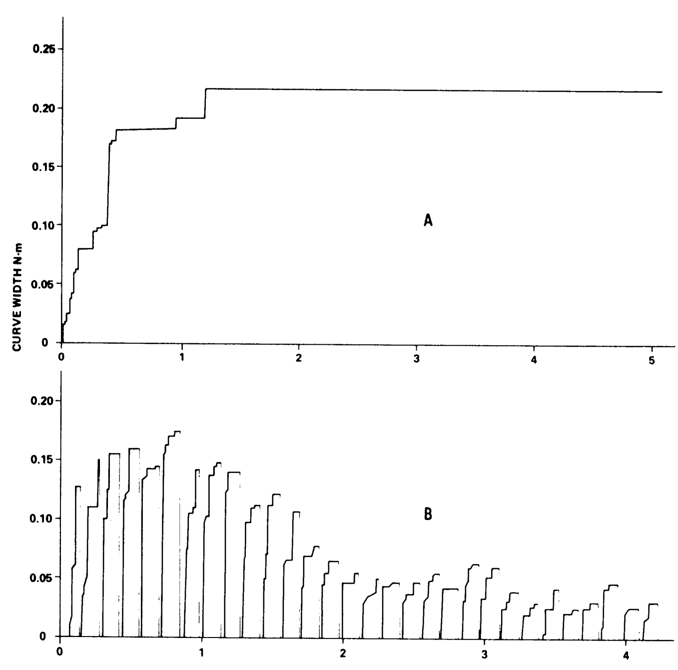

Fig. 5. Typical records for the 50:50 flour mixture. **A,** curve width; **B,** curve width changes during mixing.

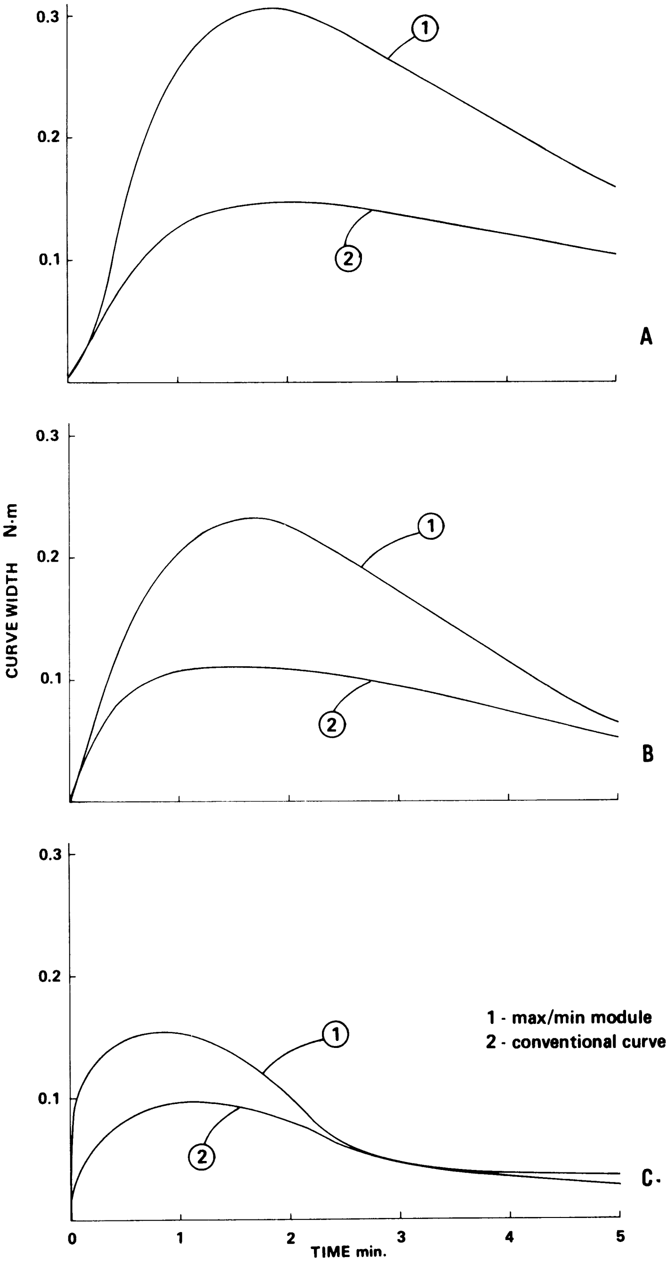

Fig. 6. Comparison of curve width readings obtained with the maximum/minimum module (1) and the analogue records of mixing torque (2). **A,** hard flour; **B,** 50:50 hard/soft flour mixture; **C,** soft flour.

demonstrates that fluctuations occur in the average mixing torque when the Mixograph is used. The physical significance of the fluctuations (eg, mechanical, chemical, or rheological) is worthy of futher study. The overall shape of the mean curves corresponded closely to those of the conventional curves.

These results demonstrate that recording methods for electronic mixers can be extended to better record energy and average mixing torque, aid curve interpretation, and obtain a precise measure of

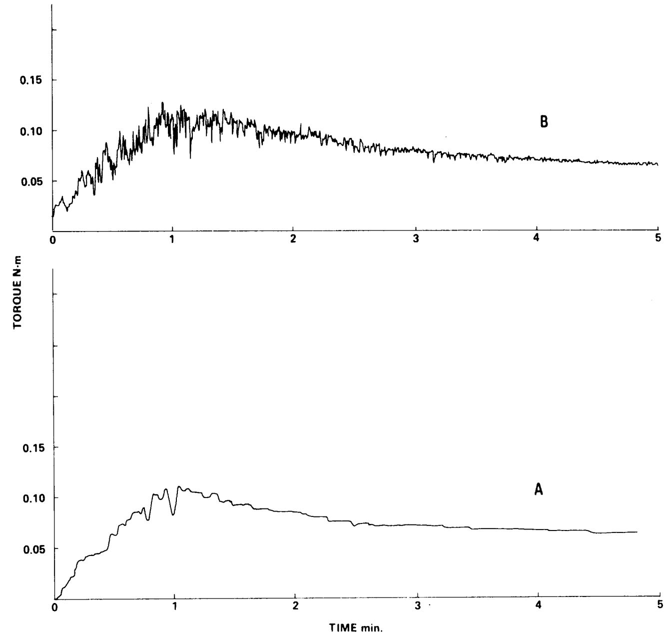

Fig. 7. Typical records of average mixing torque for soft flour obtained from the ripple module. Filter selections: **A,** output 3 Hz and module 2 Hz; **B,** output 10 Hz and module 2 Hz.

curve width. Such techniques also have potential for speeding up dough mixing tests by automating test and interpretation methods.

LITERATURE CITED

TIMBERS, G. E., PATON, D., and VOISEY, P. W. 1976. Modifications to improve the operational efficiency, process control and versatility of the Brabender laboratory extruder. J. Can. Inst. Food Sci. Technol. 9:232–237.

VOISEY, P. W. 1971. Modernization of texture instrumentation. J. Texture Stud. 2:129–195.

VOISEY, P. W., BENDELOW, V. M., and MILLER, H. 1970. Electronic recording mixers for the baking test. Cereal Sci. Today 15:341–344.

VOISEY, P. W., and KILBORN, R. H. 1974. An electronic recording Grain Research Laboratory mixer. Cereal Chem. 51:841–848.

VOISEY, P. W., and MILLER, H. 1970. The Ottawa electronic recording dough mixer. VII. Factors affecting performance and the use of digital recording techniques. Cereal Chem. 47:207–219.

VOISEY, P. W., MILLER, H., and BYRNE, P. L. 1971. The Ottawa electronic recording Farinograph. Cereal Sci. Today 16:124–131.

VOISEY, P. W., MILLER, H., and KLOEK, M. 1966a. An electronic recording dough mixer. I. The apparatus. Cereal Chem. 43:408–419.

VOISEY, P. W., MILLER, H., and KLOEK, M. 1966b. An electronic recording dough mixer. III. Additional methods of recording. Cereal Chem. 43:433–437.

VOISEY, P. W., MILLER, H., and KLOEK, M. 1966c. An electronic recording dough mixer. IV. Applications in farinography. Cereal Chem. 43:438–446.

VOISEY, P. W., MILLER, H., and KLOEK, M. 1967. An electronic recording dough mixer. V. Measurement of energy used in a Mixograph-type mixer. Cereal Chem. 44:359-372.

VOISEY, P. W., PATON, D., and TIMBERS, G. E. 1977. The Ottawa starch viscometer—A new instrument for research and quality control applications. Cereal Chem. 54:534–557.

ZALIK, S., and OSTAFICHUK, M. 1960. Note on a method of appraising mixogram data. Cereal Chem. 37:105–106.

[Received May 27, 1980. Accepted August 19, 1980]