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DYNAMIC MEASUREMENTS OF STRATIFIED CONSOLIDATION IN A PRESS NIP

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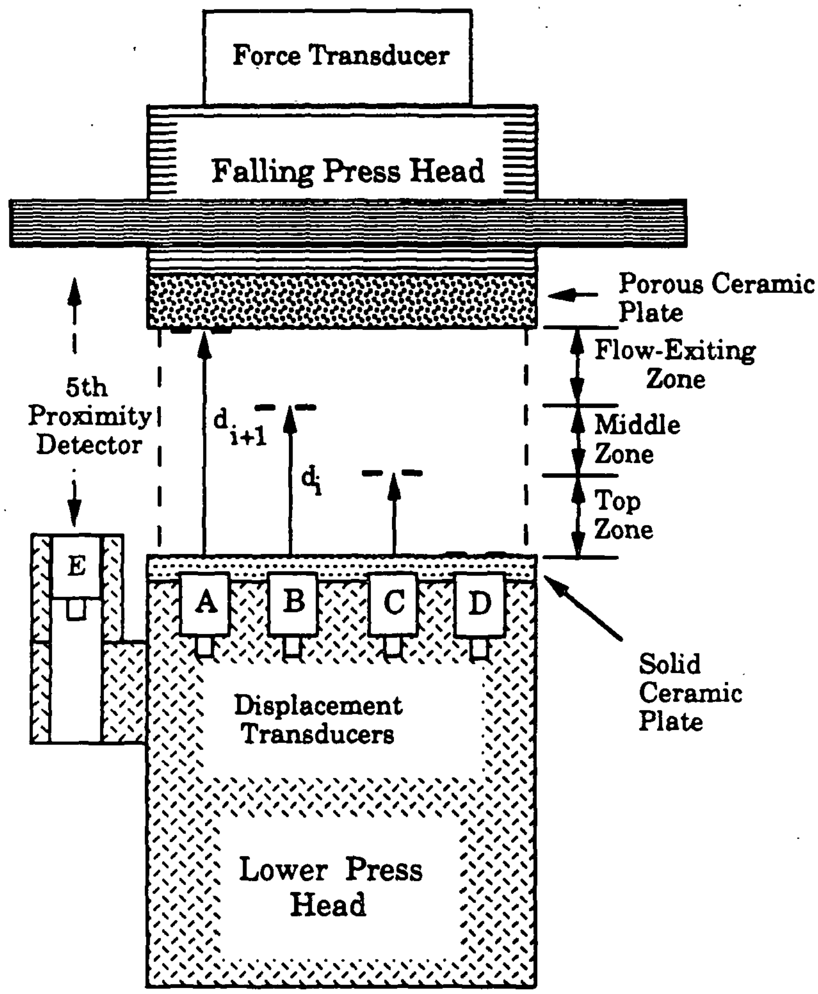

Figure 3. Schematic of new press heads with a sheet in which the solid platen zone (SPZ), the middle zone (MZ), and the flow-exiting zone (FEZ) are defined.

To determine the true beginning and end of the nip, a fifth proximity detector was added to track the location of the falling platen. The nip is closed when the upper platen position corresponds to the position of the upper target on the surface of the paper. In practice, mechanical flexing of the transducer support assembly or of the entire platen assembly sometimes made detection of nip closure and opening difficult.

The typical nip residence time for this press simulator was on the order of 3 to 4 ms, similar to that of a high-speed industrial wet press. The peak pressures generated in this nip ranged were typically 2 to 3 MPa in this study, well below those found in commercial press nips (7to 10 MPa).

Electro-Hydraulic Press Simulator

In addition to tests with a falling-weight press simulator, a series of tests was also conducted using an electrohydraulic press apparatus based on an MTS (Materials Testing Systems) ram. This press simulator allowed longer nips to be studied (>10 ms) than was possible in the falling-weight press simulator and offered a variety of instrumentation advantages. For these experiments, the upper press head was modified by the addition of an extension shaft. The upper press head and extension shaft were screwed directly onto the hydraulic piston of the MTS. This upper press head consisted of three circular aluminum plates and a porous ceramic plate as shown in Figure 4. The largest plate served as the target for the fifth proximity detector. The lower press head was mounted on the fixed base of the MTS. Carbon paper-paper nip impressions were made to ensure that the press heads were parallel.

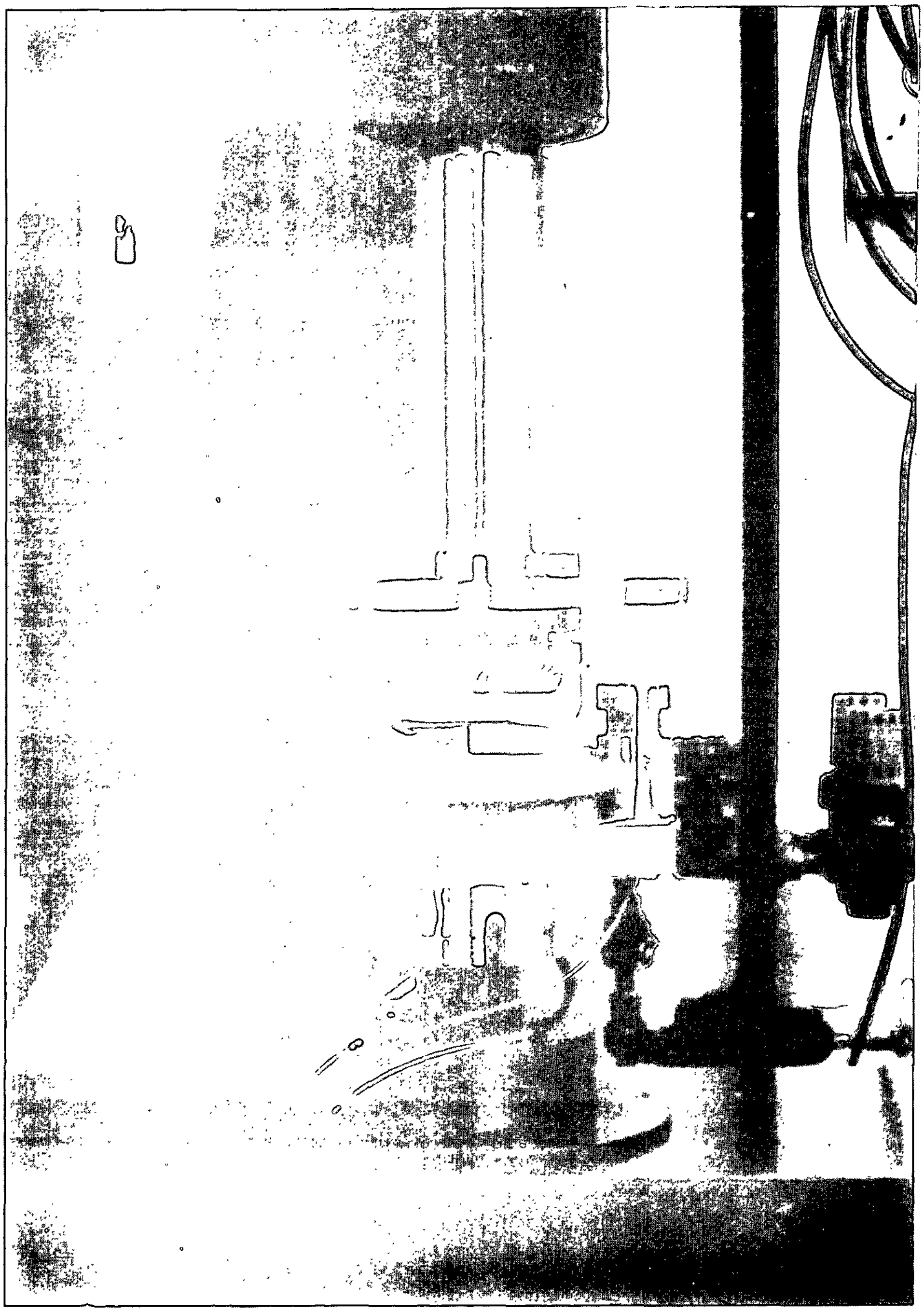

Figure 4. Upper press head with extension shaft mounted on the MTS.

Eddy Current Proximity Detectors

The five proximity detectors used in this study were of the eddy current type manufactured by Kaman Instrumentation Corp. (Colorado Springs, Colorado). These transducers have a measuring range of 4.0 mm (0.160 inches) with a resolution of 0.01% of full scale calibration. A full description of these proximity detectors, their specific requirements for proper operation, and the methods we used for calibration are described in Burns (18).

Data Acquisition System

A new data acquisition system was chosen to replace the two eight-bit resolution data acquisition systems used by Burton (16). An MDAS 7000 data acquisition system (TransEra Corp., Provo, Utah) was chosen. The 12-bit data acquisition system resolved the signals into 4096 different levels. The system was set up for each run to acquire 1000 data points, of which 450 were recorded before the system was triggered. The sampling frequency was typically 10 kHz or greater.

Dynamic Density Profile Determination

To press the handsheets in the press simulators, the 127-mm (5-in diameter) handsheets were cut with a die cutter to a diameter of 96 mm (3.75 in) to match the size of the falling press head, placed on the lower press head, and aligned with the eddy-current transducers. A small pressure of 17.9 kPa was applied to the handsheet prior to pressing to improve the contact of the bottom target with the solid ceramic platen. The feedback control system of the MTS was adjusted to yield the desired peak applied pressure and nip residence time, and the handsheets were pressed. (The pressure profile generated by the MTS unit was always a slightly asymmetric haversine pulse. This asymmetry is typical of the pressure profiles measured in industrial wet press nips.)

During the pressing of the sheet, the targets moved with the surrounding fiber network in response to dewatering and densifying forces. The instantaneous density for each zone was calculated from the corresponding zonal thicknesses and the zonal basis weights using Equation (2) above.

To obtain a consistent moisture content in the porous ceramic flow receiver for each handsheet, it was necessary to adjust the moisture content of the ceramic flow receiver. After the first sheet was pressed in each handsheet series, the moisture content in the porous ceramic flow receiver was reduced by pressing blotters in the press nip until it was not possible to detect any further water pickup by the blotters.

RESULTS AND DISCUSSION

A large set of data was acquired for 150 g/m^2 handsheets. Much of the data was acquired in the process of improving the methods and equipment for this study. The data set acquired after the techniques and equipment reached their final state of development comprises measurements in 22 samples. These samples include both high- and low-freeness softwood handsheets and low-freeness hardwood handsheets which were pressed with either the falling-weight press simulator or the MTS servo-hydraulic press. A sampling of the results will be presented here; complete details are given by Burns (18). Results for each set of conditions were typically replicated three times.

Below, we refer to the zone adjacent to the porous ceramic plate (flow receiver) as the flow-exiting zone (FEZ). The next zone is the middle zone (MZ), followed by the solid platen zone (SPZ).

Falling-Weight Press Simulator

The displacements of the targets embedded in a softwood handsheet are shown in Figure 5. The handsheet was formed from a low-freeness (353 CSF) kraft softwood furnish and had an initial moisture ratio of 4.31. The displacement profiles of the falling press head (target E, labeled "Head") and the target on the top of the sheet (A) are similar in shape. The head appears to have made good contact with this handsheet and remained in contact with the sheet for a long period of time, but this was not always observed. In many cases, rocking or tilting of the falling head may have occurred. Even in this figure, the head and target A seem to have moved at different rates (the lines have different slopes), which is an indication that the falling press head hit the handsheet first on one side and then leveled off before rebounding. There is also some motion seen in target D, though it is much less than that seen in Burton's results and has little effect on the results. It is possibly due to deformation of the lower head or imperfect initial contact between the target and the lower platen.

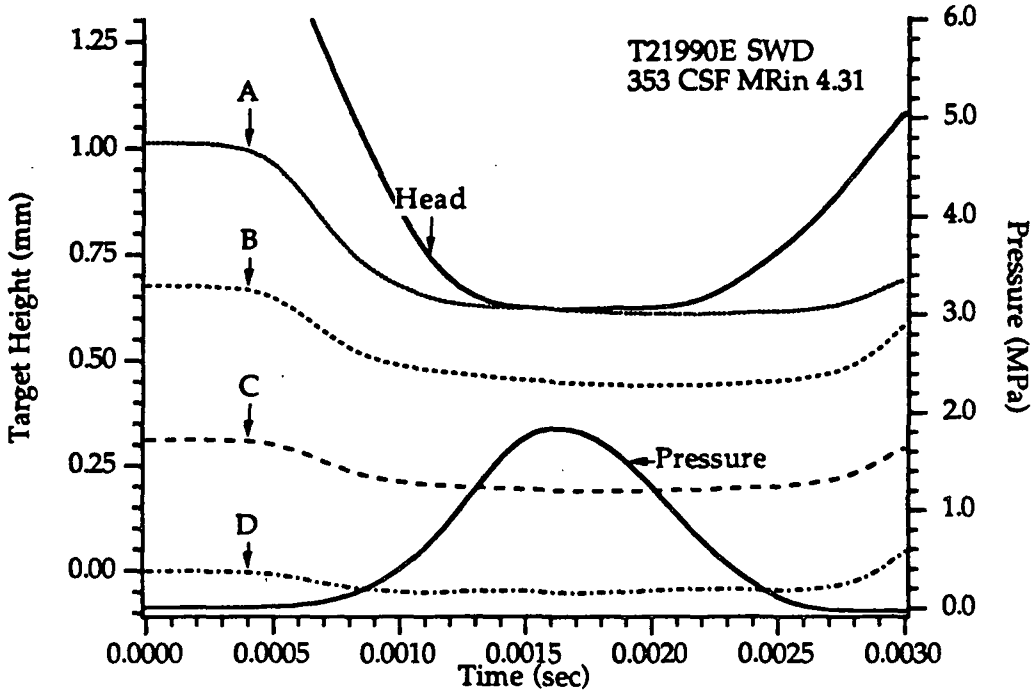

Figure 5. Target displacement histories for a low-freeness kraft softwood handsheet. Basis weight = 150 g/m^2; moisture ratio = 4.31; freeness = 353 CSF.

The rates and extents of target displacements in this handsheet were significantly less than those seen in a high-freeness softwood handsheet for the same nip residence time and peak applied pressure. There was little compression of the handsheet after the initial rapid compression, and the sheet reached a minimum compression height of 0.62 mm just after the point of maximum pressure. Subsequently, the sheet expanded slowly to a height of 0.68 mm as the pressure in the nip reached zero. After the pressure was reduced to zero, the target displacement profiles became erratic. This behavior is typical of unrestrained expansion of the sheet and lift off of the sheet from the solid ceramic plate.

The corresponding zonal densities (mass of dry fiber per unit volume) of the low-freeness handsheet discussed above (see Figure 5) are shown in Figure 6. There was little difference in the

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