Guidelines for selecting uhle-box slot width

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ABSTRACT *The effect of uhle-box slot width on water removal from press felts was analyzed using mathematically generated profiles of escape velocity and acceleration. Profiles were created for a variety of production conditions. The results demonstrate the importance of sufficient dwell time for effective dewatering. A single slot is shown to provide better dewatering than two slots with the same open area.*

KEYWORDS
Felt conditioning
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Press sections
Vacuum
Water removal

The uhle box removes water from press felts by applying a vacuum through either one or two slots. The width of the slot—not the total open area—is the controlling variable in optimizing the water-removal capability of the uhle box. The two factors that determine optimum slot width are machine speed and available vacuum. Single-slot uhle boxes are more effective dewatering devices than double-slot uhle boxes of the same open area. This relationship is even more pronounced when the slots on the double-slot uhle box are relatively small for the machine speed.

The relative relationship between slot size and machine speed can be determined by some simplified calculations. For any given machine speed and slot size, the residence time over the slot is fixed. Thus the average lineal velocity can be calculated for any given distance that the water must travel to escape the felt. Because of the short distances and brief time intervals involved, the calculations are based on the presumption of linear acceleration. Therefore, maximum or escape velocity will be twice the average velocity. The distance that the water travels is the distance from its position within the felt to the surface of the felt plus a finite distance sufficient to break free of the felt surface.

Principles

Figure 1 depicts escape velocity as a function of slot width for machine speeds ranging from 500 ft/min to 4000 ft/min. The calculations are based on water traveling a total distance of 0.08 in. The uhle-box air flows ($ft^3/min/in.^2$) are provided as a reference on the right vertical axis, since air flow is actually a measure of velocity. An air flow of 5 $ft^3/min/in.^2$ is equal to 144 in./s.

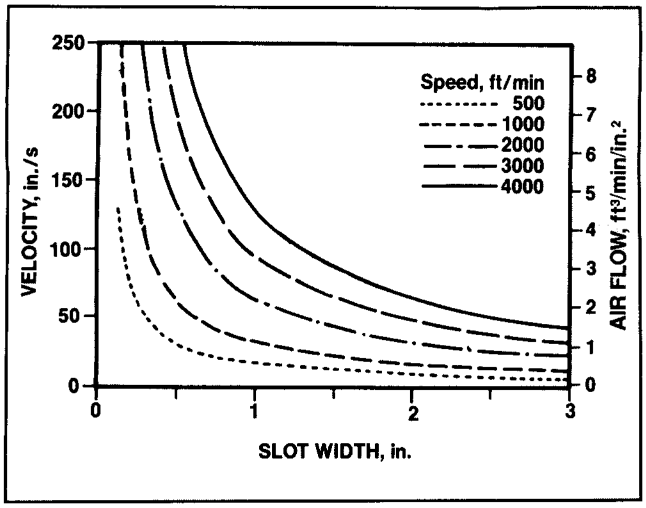
The escape velocity for the 1000-ft/min curve begins to turn up very rapidly at slot widths below 0.5 in. A 0.5-in. slot width is thus the "turning point" for a machine operating at 1000 ft/min. Slot widths below the turning point for a given speed are too small. The turning point for 2000 ft/min is about 0.75 in. Similarly, the turning point at 3000 ft/min is about 1 in. It is apparent that a uhle box with a 0.5-in. slot and an air flow of 7 $ft^3/min/in.^2$ would be incapable of effective water removal on a machine running at 3000 ft/min. Because the escape velocity is higher than the air velocity, little if any water would be removed under these conditions.

Escape acceleration can be calculated based on the residence time and the escape velocity. **Figure 2** is a plot of escape acceleration vs. slot width for machine speeds ranging from 500 ft/min to 4000 ft/min. At slot widths below the turning point, the slope of each acceleration curve is greater than that of the associated velocity curve. At 2500 ft/min, an acceleration of about 100 g is required to reach escape velocity over a 1-in. slot, while about 400 g is required to reach escape velocity over a 0.5-in. slot. Thus, as the slot width decreases below the turning point, the driving force necessary to remove water increases radically. **Figures 3** and **4** present the same data as Figs. 1 and 2, respectively, but in a different format.

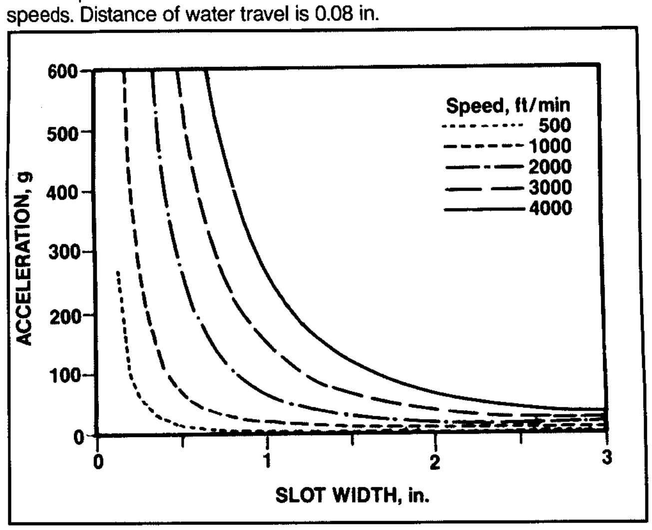
Figure 5 shows escape velocity as a function of slot width for total water-travel distances of 0.04 in., 0.06 in., 0.08 in., and 0.10 in. The machine speed is 2000 ft/min. **Figure 6** shows escape acceleration under the same set of conditions. Both figures show that for a given slot width and machine speed, there is a range of escape velocities and escape accelerations that increases as the depth of the water in the felt increases. This is also apparent from **Fig. 7**.

The driving force that accelerates

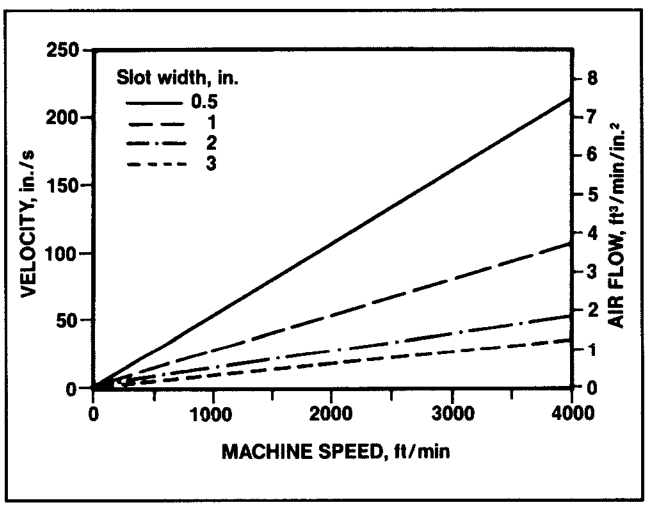
1. Escape velocity as a function of slot width at five machine speeds. Distance of water travel is 0.08 in.



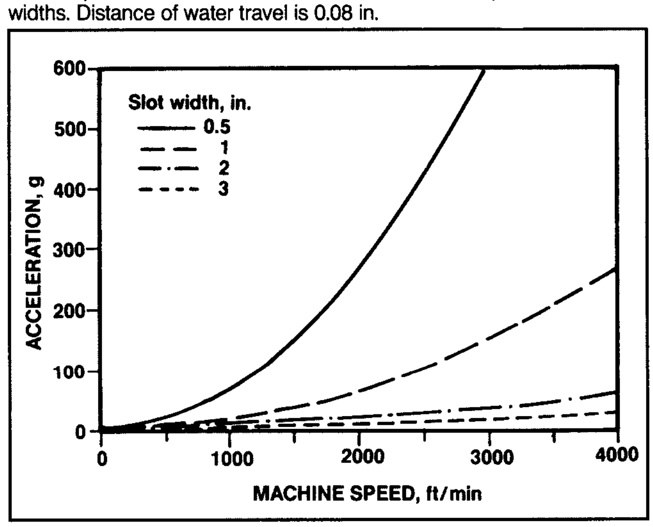
2. Escape acceleration as a function of slot width at five machine speeds. Distance of water travel is 0.08 in.



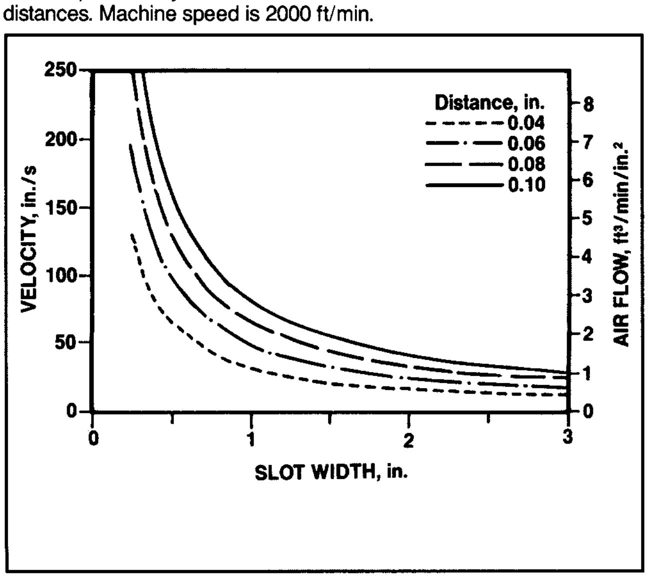
3. Escape velocity as a function of machine speed at four slot widths. Distance of water travel is 0.08 in.



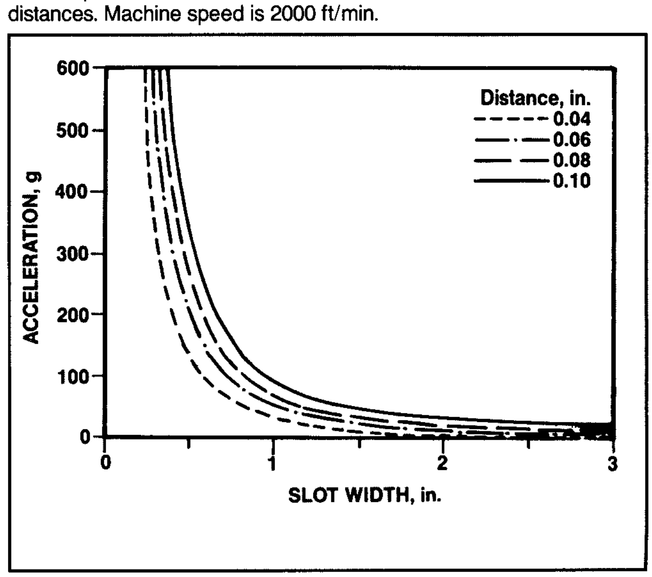
4. Escape acceleration as a function of machine speed at four slot widths. Distance of water travel is 0.08 in.



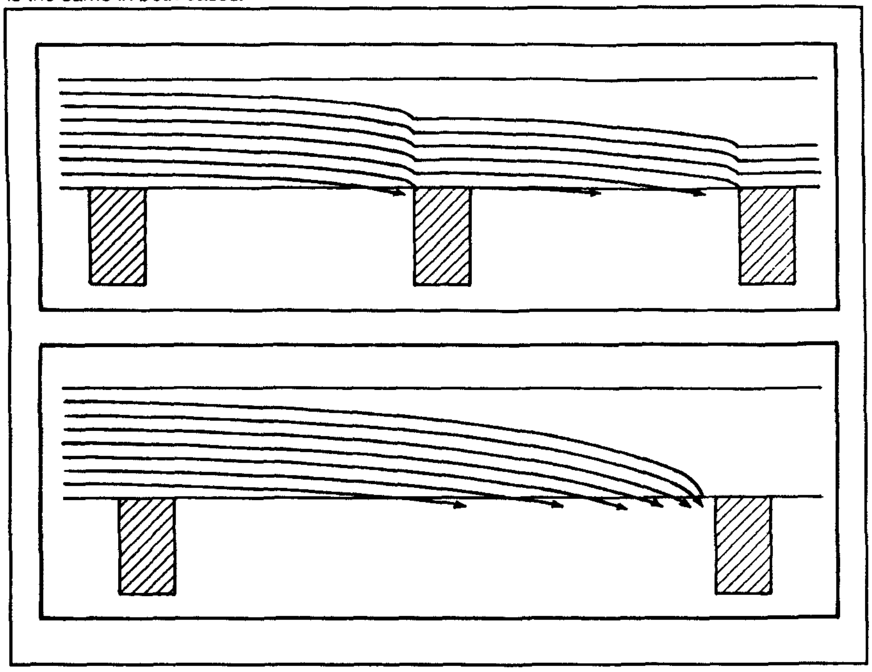
5. Escape velocity as a function of slot width at four water-travel distances. Machine speed is 2000 ft/min.



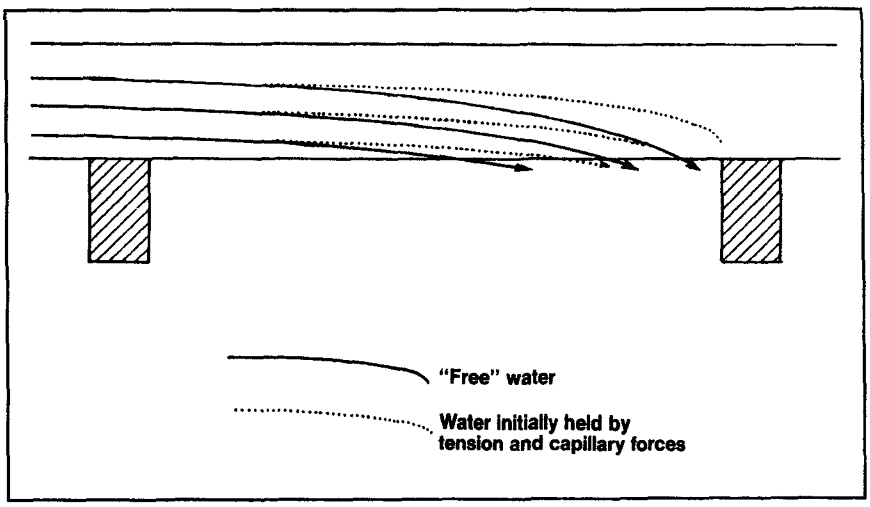
6. Escape acceleration as a function of slot width at four water-travel distances. Machine speed is 2000 ft/min.



7. Water movement over a double-slot box (top) and a single-slot box (bottom). The open area is the same in both cases.



8. Movement of free and bound water over a single-slot uhle box



I. Distance of felt travel over uhle slot before bound water begins to move

Machine speed, ft/min	Distance, in. 0.0005-s delay	0.001-s delay	0.002-s delay
500	0.05	0.1	0.2
1000	0.1	0.2	0.4
2000	0.2	0.4	0.8
3000	0.3	0.6	1.2
4000	0.4	0.8	1.6

the water through the felt is the difference between the air velocity and the water velocity in the felt. Thus, to achieve an increase in acceleration, a greater-than-proportional increase in air flow is necessary. Figure 7 shows how the smaller slot widths of a two-slot box disrupts the water-removal process by interrupting and flattening the rapidly descending portion of the curves. A slot that is too narrow for a given machine speed may still remove water, but only that which is close to the surface. The factors that determine the depth to which water is removed are slot width and air flow. The lower figure shows that a single slot of the same open area is a much more effective dewatering device.

Only the "free" water—the water that responds quickly to the air flow—has been addressed thus far. However, DeCrosta has noted that some of the water is held more strongly by surface tension and capillary forces.* The greater the time available for air to flow over this "bound" water, the greater is the portion that will be removed, as illustrated in Fig. 7. This further supports the assertion that, given the same open area, a single slot provides greater dewatering than a double slot.

Figure 8 shows that the movement of bound water is delayed by an amount proportional to the degree to which it is bound. The delay in movement has the effect of shifting the curves in Figs. 1 and 2 toward the right. This effect is more pronounced at high speeds. To illustrate this concept, time delays of 0.0005 s, 0.001 s, and 0.002 s were selected. **Table I** shows the distance the felt travels over the uhle box at machine speeds of 500–4000 ft/min for the chosen time delays. The 4000-ft/min curves in Figs. 1 and 2 will be offset 0.8 in. to the right for any water that is delayed 0.001 s, while the 500-ft/min curves will be offset by only 0.1 in.

Practical applications

Optimum uhle-box slot width, for a fixed vacuum supply, is the point at which the loss of dewatering resulting from decreasing velocity ($ft^3/min/in.^2$) equals the gain in dewatering from

*DeCrosta, E. F., Tappi 56(11): 100(1973).

increased dwell time. The greatest gains in dewatering resulting from an increase in dwell time occur in the area where the curves in Figs. 1 and 2 are descending rapidly.

The only justification for double-slot uhle boxes is to reduce felt wear by reducing felt sag into the slot. However, double-slot uhle boxes utilize vacuum in a less efficient manner than single-slot boxes, and in some cases may cause the felt and consequently the press to run wet. If the latter occurs, reduced machine speeds and/or poor runnability are the results.

The standard herring-bone box is actually a double-slot box, since the felt passes over at least two slots as it traverses the box. However, a single-slot herring-bone cover, in which most of the felt passes over a single slot, would be an effective dewatering device. On high-speed machines, it will provide the requisite high dwell times without causing excessive felt sag into the slot.□

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