

A new look into the uhle dewatering process

This article, by LUCJAN RAUBIC¹ was submitted for publication

SUMMARY

This article describes a method for improving efficiency of uhle boxes in the process of paper manufacturing. The essence of this method is the use of a homogeneous mixture of superheated humid air in the press section of a papermachine. A very intense mixing of air and steam takes place in the steam jet ejector, which creates a uniform mixture, with appropriate composition and temperature, directed to the blow box. The steam jet ejector keeps an optimum vacuum level without a vacuum pump. The mixture is then used in the forced flow through the felt to a suction slot installed under the felt. The correct mixture composition ensures its minimum density, maximum speed and minimum

time of flow through felt. This is important because the flow takes place when felt is running fast. The time ratio of the flow of homogeneous mixture of superheated humid air versus longitudinal movement of felt equals the actual working surface area of the suction slot. Extended working area and dwell time directly influences the quality of felt conditioning and paper dewatering in the press section.

¹President
VenPap System Ottawa
E-mail: venpap@venpap.com

Introduction

Uhle boxes are used in the paper making process to condition press felts. These boxes are in fact vacuum pipes with slots of different size and shape (straight slots or herringbone) directed towards the inside. Air is drawn through the felt, which is moving over slots,

by a vacuum pump. During the process water and other contaminants from the felt are removed together with the air. This is a crucial stage for effective paper dewatering in the press section.

The uhle box dewatering problem.

Current paper machines run at a speed much higher than the speed of air flowing through the felt. The cross-directional movement of a fast moving felt versus airflow leads to a deflection of the air stream in the direction of the running felt and therefore causes considerable reduction in the working surface of a uhle box. This is illustrated in Figure 1. In the case of very fast papermachines this can lead to a total cancellation of the open air flow surface and consequently hinder felt conditioning.

Deflection of uhle box air flow is a result of Bernoulli's Principle and Darcy Weisbach's Law. This phenomenon occurs on every papermachine and it is known as the 'Uhle Paradox' (Fig. 2)

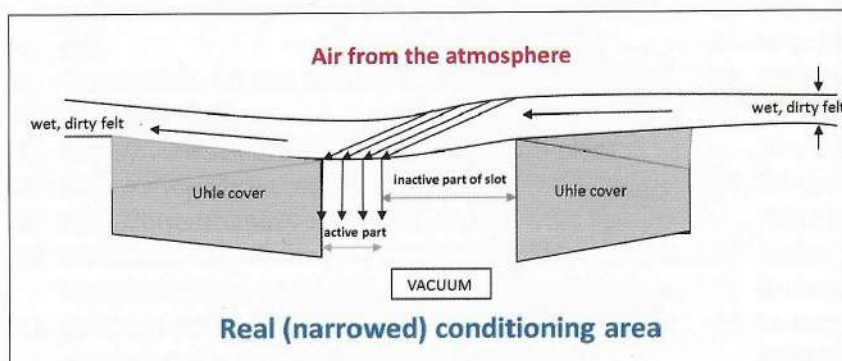


Fig. 1. Speed difference between felt and airflow through uhle box

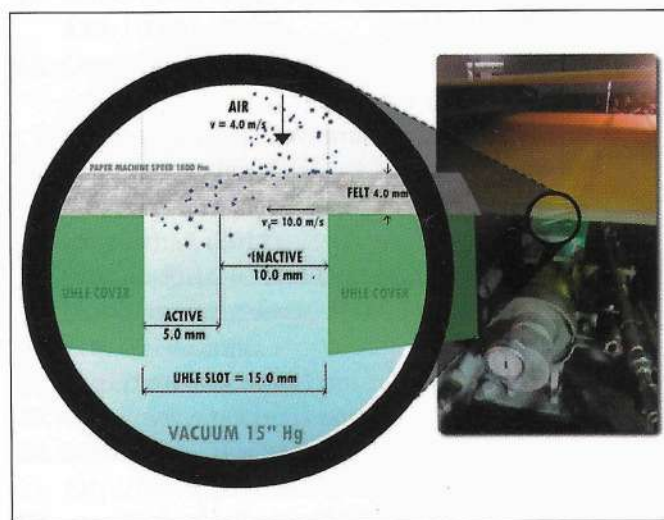


Fig. 2. The 'Uhle Paradox'

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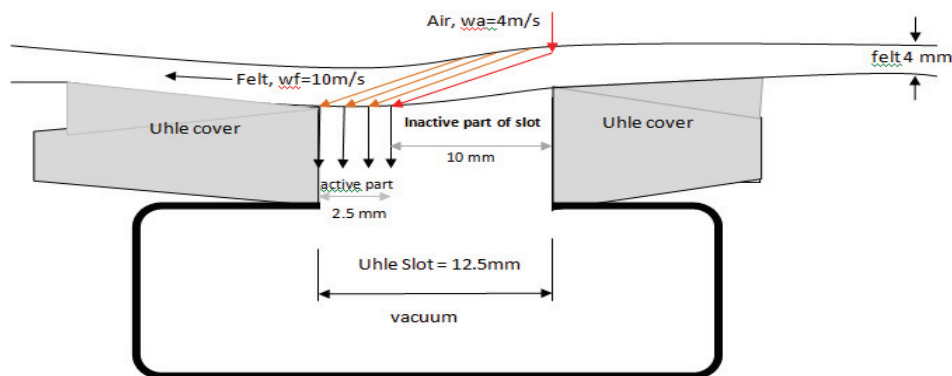


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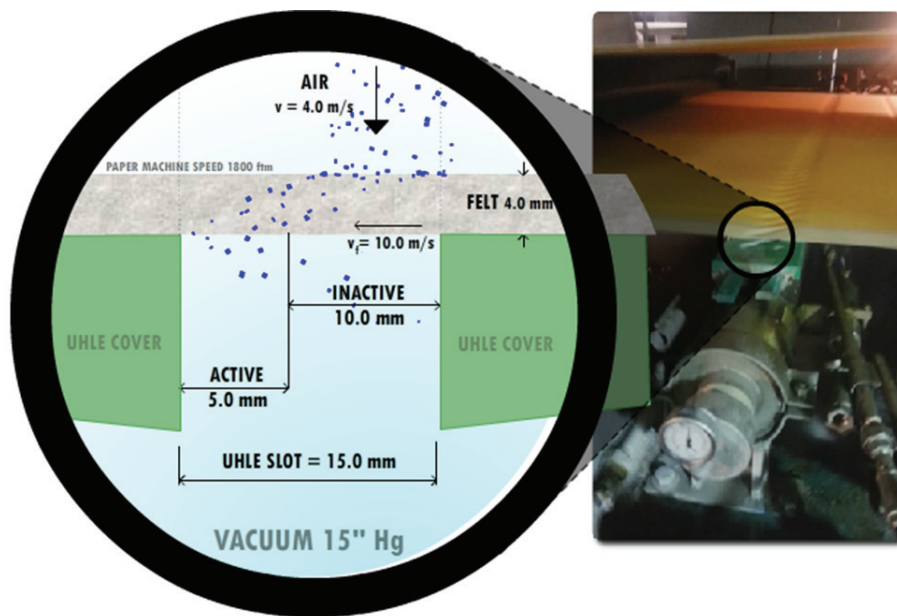


Fig. 2 The 'Uhle Paradox '

What exactly is 'dwell time'?

Dwell time is the amount of time during which the felt is positioned in the active area of the uhle box. The minimum dwell time specified and recommended by felt producers is 2 – 5 ms. Below that value felts fail to be properly conditioned.

Narrowing the open area reduces the actual dwell time to a level of 0.5 ms. The consequence of this is that felt conditioning with dwell time of less than 1ms is minimal or nonexistent.

How can the air flow through the felt be improved?

The Darcy-Weisbach Equation is given as

$$\Delta p = \lambda (l/d) \times (\rho v^3) / 2 \quad [1]$$

where Δp – vacuum level (constant for a given uhle box);

λ – Darcy friction coefficient depending on contamination, felt compaction;

l/d – geometric coefficient (constant for a given uhle box);

ρ - density of air;

v - velocity of air, given by
$$v = \text{constant} \sqrt{\frac{1}{\lambda \rho}}$$

The correct composition of the superheated humid air mixture ensures its minimum density, minimum friction coefficient and maximum speed, as shown in Figure 3.

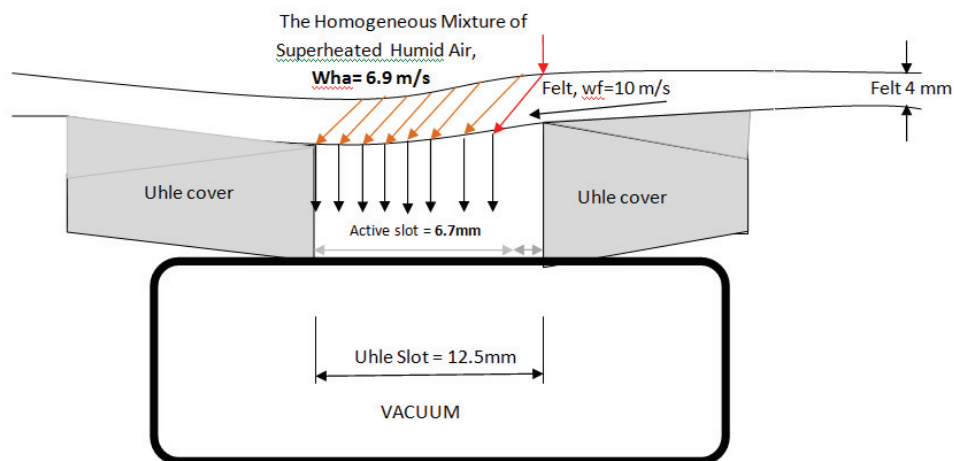


Fig. 3. effect of optimising the superheated humid air composition

The correct mixture composition is important to ensure air flow is optimised when the felt is running fast. The time ratio of the flow of homogeneous mixture of superheated humid air versus longitudinal movement of the felt equals the actual working surface area of the suction

slot. In order to accomplish maximum speed flow through felt it is necessary to reduce the density and friction coefficient to a minimum.

1. Density.

The homogeneous superheated humid air is around 2.5 times less dense than atmospheric air (Fig. 4). According to equation [1] the velocity of the mixture flow through felt is inversely proportional to the square root of the density. Reducing the density will therefore increase the flow velocity of the mixture in relation to clean air $\sqrt{2.5} = 1.58$ times. This in turn shortens the time of the mixture flow and reduces the deviation of the stream through the moving felt.

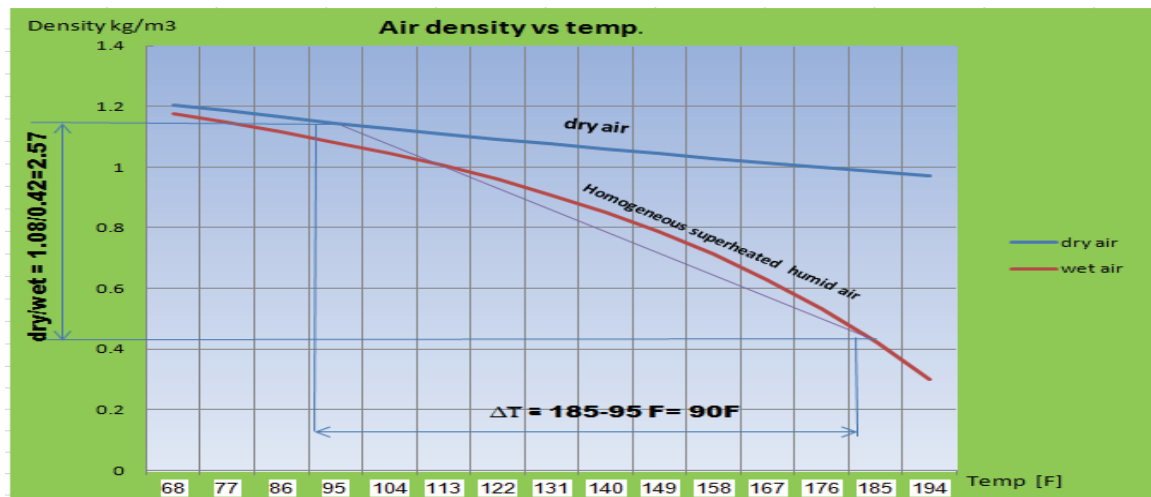


Fig. 4. Air density versus temperature for superheated and dry air

2. Friction coefficient

The Darcy friction coefficient (λ) depends on contamination, felt compaction and water content. Each of those variables depends on the intensity of felt conditioning (known as dwell time) and the temperature at the uhle box. Figure 5 illustrates the relationship between friction coefficient and dwell time

The process is as follows:

1. Reducing air density increases flow velocity and dwell time.
2. Increased dwell time and temperature decrease the friction factor.
3. Reduced friction increases flow speed and dwell time.
4. Further increased dwell time decreases water content and contamination in the felt until maximum active surface of Uhle is accomplished.

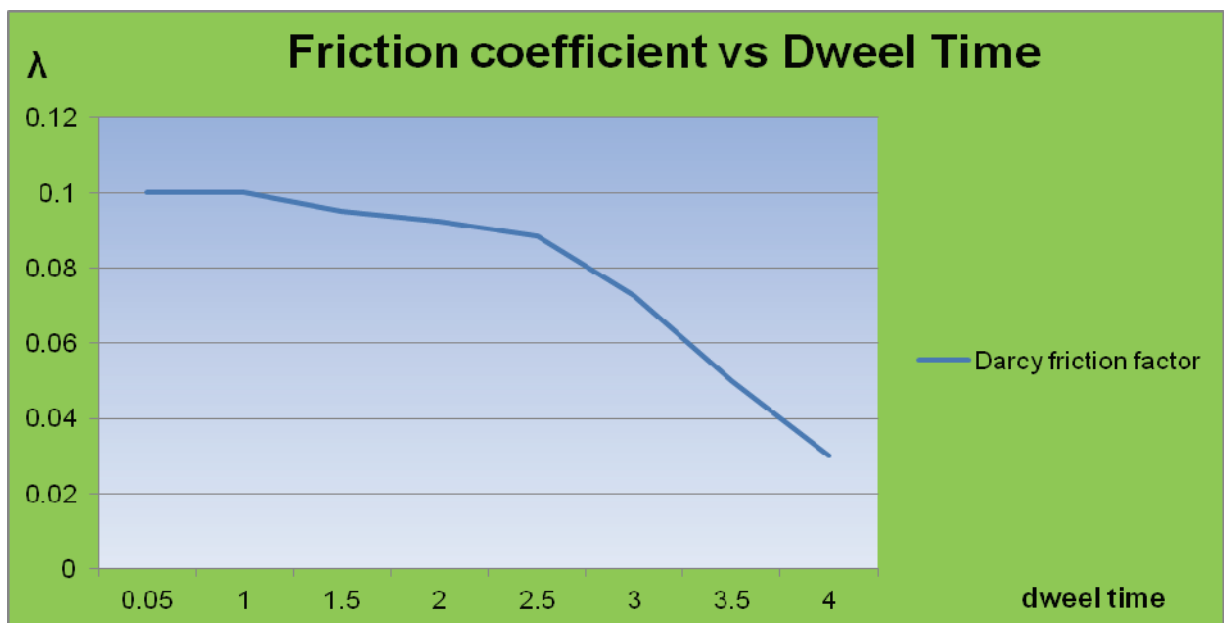


Fig. 5. Relationship between friction coefficient and dwell time

Uhle box efficiency.

The dwell time of felt in the open area of the uhle box is crucial because it directly impacts water and contaminants removal from felt. A portion of the moisture evaporates and is sucked away. The remainder of the water in the liquid form is substantially easier to vacuum off at higher temperatures due to decrease in its viscosity and density.

As a consequence, simultaneous vacuuming and preheating of the felt by means of an air-steam flow improves paper dewatering in the press section of the paper machine. As a result, the paper web will have a higher dryness after the press section (Fig. 6).

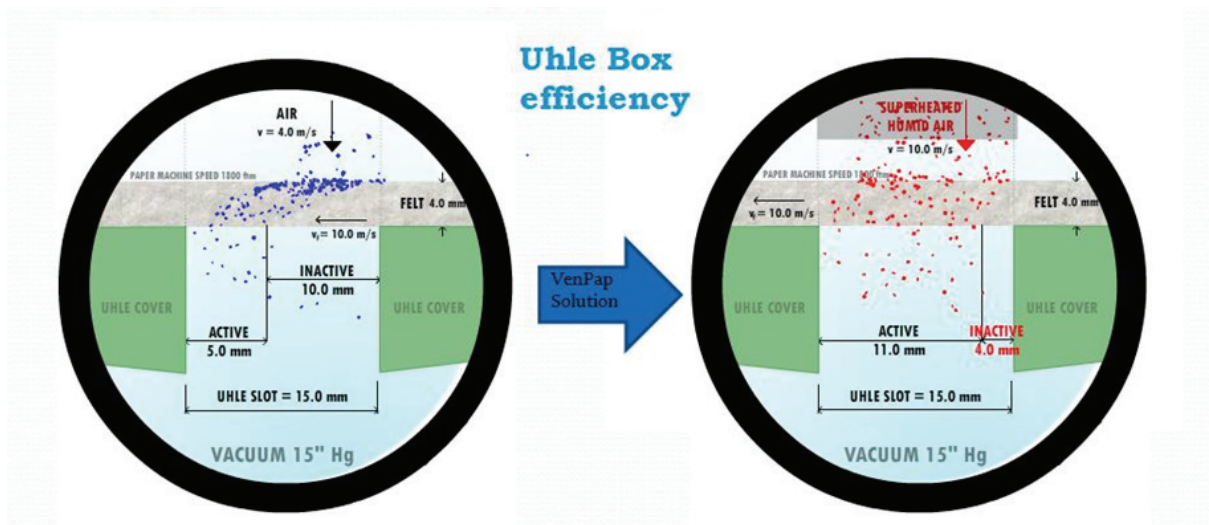


Fig. 6. Using superheated humid air instead of dry air improves the active area of the uhle box slots.

Solution.

The 'VenPap Unit' uses a homogeneous mixture of superheated humid air in the conditioning process. A very intense mixing of air and steam takes place in the steam jet ejector, which creates a uniform mixture, with appropriate composition and temperature, directed to the blow box. The mixture is then used in the forced flow through the felt to a suction slot installed under the felt. The steam jet ejector keeps the optimum vacuum level without the need for a vacuum pump. The benefits of using the unit are shown in Figure 7, which in this case reduced steam consumption in the dryers by 11.6%.

How important is the improvement of Uhle Dewatering ?

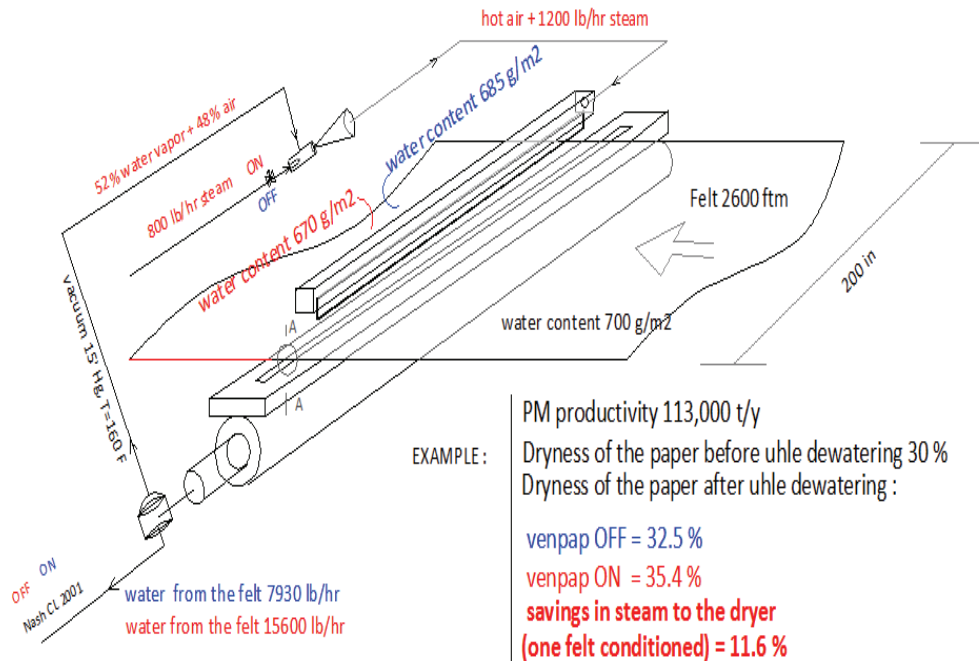


Fig. 7. Benefits of the VenPap Unit

A pilot unit is installed at the American Eagle Paper Mill, Tyrone, PA, USA. Scott Igoe, VP of American Eagle Paper Mill, said "...Further, it's thanks to the optimal vacuum level in the uhle box, the perfect temperature and intensified permeability, that we are able to accomplish increased dewatering in the press sections. As a result, we are capable of speeding up paper machine #3 while reducing production costs by 8% "