AIR FLOW IN AN AIRBORNE DRYER

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Introduction

The airborne dryer is perhaps the least understood piece of equipment in a pulp mill. It is a simple device which operates reliably, and there has been little need to develop a general understanding of how to tune it up. Although there are 41 airborne dryers in Canada and at least 24 more in the USA there is virtually no literature and virtually no research on this topic.

Recently it has been demonstrated that there is the potential for up to 15% increase in evaporative capacity as well as substantial maintenance savings by optimizing the design of components. It is time to develop an understanding of the inner workings of airborne dryers to the same degree as we have with recovery boilers and continuous digesters.

This paper is intended as a first step in that direction. The key to understanding how a dryer operates is to understand the air flow pattern. This information has been accumulated by the author in the course of developing a training course on pulp drying and in working with Daken Enterprises in the promotion of their Super Coils™.

This information is applicable to all generations of Flakt dryers and to Ross dryers.

Overview Of Air Usage

In an airborne dryer, air is used to:

- support the sheet
- transfer heat to the sheet
- carry evaporated water vapour away from the dryer

The first two functions are obvious, the third less so. It is however the third which defines the overall air flow requirement.

A dryer will be designed to use about 4 kg of dry air per kilogram of water evaporated. The exhaust air will typically have a dry bulb temperature of 130^{o}C, and a dew point of 70^{o}C. This allows for the transfer of a substantial amount of heat to the incoming makeup air, without risk of condensation in the air-to-air heat exchanger.

In order to transfer all the heat required to evaporate the water in the pulp sheet, it is necessary to re-circulate and reheat the air about 6 times within the dryer. Air is not a particularly good medium for transferring heat to the pulp sheet, having a heat capacity of only a quarter of that of water. If all the heat were to be transferred in one pass, the air would have to be heated to over 400^{o}C, as is done in a flash dryer.

The recirculation rate through the blow boxes, is set by the need to support the sheet. The fans are sized to generate that recirculation rate, and the steam coils, which reheat the air, are then sized for the necessary heat transfer.

In the course of passing through the dryer, the air expands due to being heated and to picking up water vapour. It is normal for a dryer to be under slight vacuum at the bottom and under slight pressure at the top.

Dryer Construction

Dryers are completely modular. Figure 1 shows the cross section of a Ross dryer under construction. Rows of towers containing the fans and coils are erected on each side of the dryer, and then the blow boxes which contain and support the sheet are hung between them. The towers also support the turning rolls

Air movement within the centre section is mainly horizontal. Vertical (upward) motion occurs primarily in the coil sections in the end towers.

Figure 1: Construction of an Airborne Dryer

Makeup Air and Heat Recovery

Air for the dryer is usually drawn from inside the machine room, preferably at a point of low humidity. It is blown through an air-to-air heat exchanger to pick up heat from the

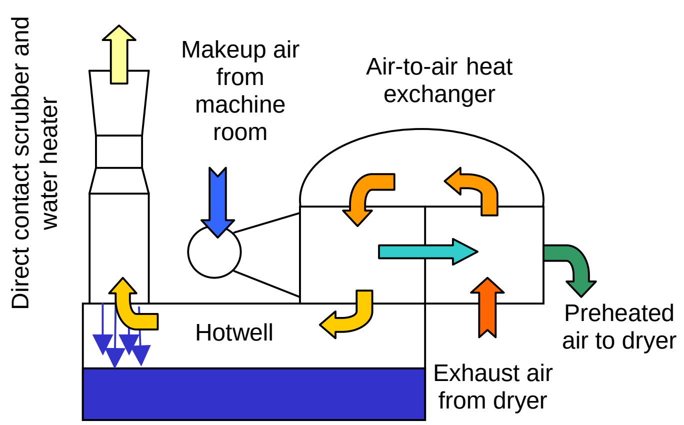

Figure 2: Air Flow External to the Dryer

exhaust air, as shown in Figure 2. The air-to-air heat exchanger has two counter-current compartments. Some of the remaining heat in the exhaust air is recovered, either directly or indirectly, into hot water in the scrubber tower

Air enters the dryer at the bottom, is re-circulated several times and exits from the top. Exhaust air goes through the air-to-air heat exchanger to lower its temperature closer to the dew-point. In the second compartment the flow is downward so that any condensation which might occur will drain into the hotwell.

Air Flow within the Dryer

The incoming air enters the dryer at the bottom of the coil compartments. In a Ross dryer it is usually preheated in a steam coil after the air-to-air heat exchanger. In order to transfer the necessary amount of heat to the pulp sheet, as well as to support the sheet, the air is re-circulated within the dryer 5 to 7 times. If a dryer has 19 decks, this means that on average the air moves up three decks on each pass. In each pass the air is reheated by about 40^{o}C to make up for the heat lost on contact with the pulp sheet.

In the Flakt type L dryer, the air enters the bottom of the dryer through selected coil compartments. There are typically two inlets for every seven coil compartments (three inlets for ten compartments, etc.). In these dryers there is a horizontal migration in the machine direction to the other coil compartments, as shown later in Figure 8. There is also air travel in the machine direction with the sheet. The air must travel at least as fast as the sheet in order to fly a threading kite.

In the Flakt FC and Compact dryers, the air enters at the bottom of every coil compartment, and there is little horizontal migration of air in the machine direction.

Blow Boxes

Heated air is delivered to the pulp sheet by blow boxes (Flakt terminology) or air headers (Ross terminology). Flakt terminology is used here, because there are more Flakt dryers. Figure 3 shows the construction of a single blow box conceptually. Flakt Type L and Ross blow boxes are tapered.

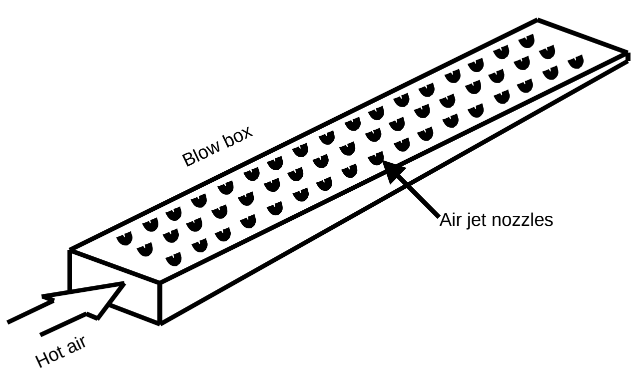

Figure 3: Blow box with Directed Air Nozzles (Type L)

Blow boxes for Type FC dryers are not tapered.

A blow box is 20 to 100 cm wide and long enough to span the centre section of the dryer. The top surface has a pattern of nozzles punched into the surface which direct jets of air up under the sheet. In Flakt Type L and in Ross dryers these jets are pointed in the direction of sheet travel, and help propel the sheet forward. In Flakt Type FC dryers, the jets are designed to position and hold the sheet at a fixed distance of about 1 mm above the blow box.

In most dryers, each lower blow box is paired with one or two upper blow boxes, as shown in Figure 4. Both are fed air from the same fan compartment, and the jets from both boxes impinge on both sides of the sheet. The upper blow boxes tend to stabilize the side-to-side position of the sheet.

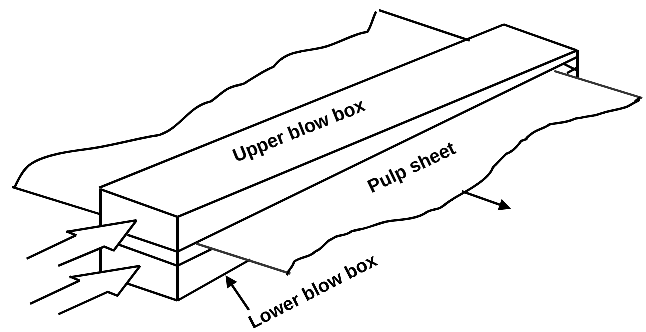

Figure 4: Upper and Lower Blow Boxes

The original Flakt Type FC dryers do not have upper blow boxes, but the FC Compact dryers do. In the FC dryer, the sheeet is held in place by the action of the air jets.

For each set of blow boxes, there will be an equivalent set being fed from the other side of the dryer, as shown in Figure 6. This balances the forces and the air delivery from each side of the dryer.

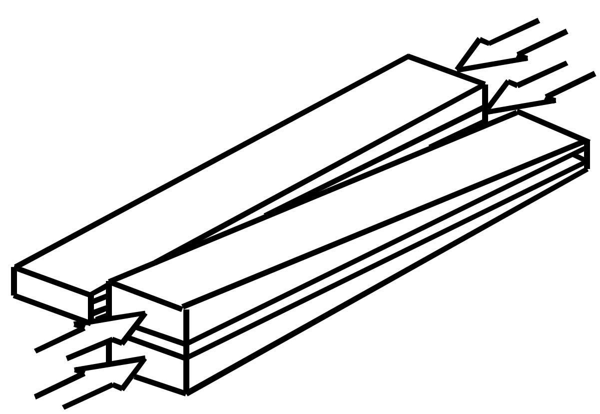

Figure 5: Opposing Blow Box Sets

Air which has contacted the sheet is vented off between blow boxes as shown conceptually in Figure 6. The air then is pulled by fans to the coil compartment on the far side of the dryer.

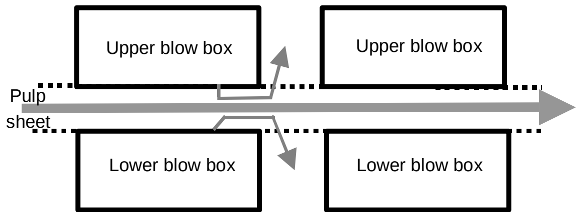

Figure 6: Concept of Air Release from the Sheet Deck

Figure 7 illustrates the sheet travel and air release from opposing sets of blow boxes.

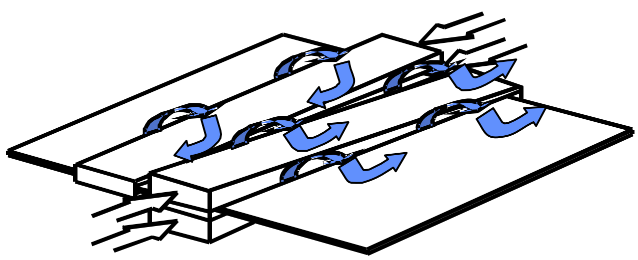

Figure 7: Blow Boxes, Pulp Sheet and Air Venting

Horizontal Air Migration

In the Type L dryer, air enters the dryer only through selected compartments. It must then migrate horizontally to all the other coil compartments. This occurs both in the sheet decks and in a series of diamond shaped spaces created within the dryer by the tapered blow boxes. Figure 8 illustrates how these spaces are created.

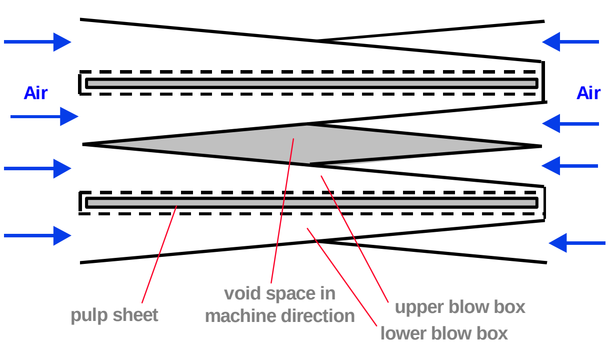

Figure 8: Machine Direction View down a Set of Blow Boxes (Type L)

Coil and Fan Compartments

The coils and recirculating fans are all located in the side towers of the dryer. Figure 9 shows a cross section of the coil and fan compartments on the sides of the dryer. These compartments run continuously from the bottom to the top of the dryer and the vertical flow of air takes place in these. The coil compartments are accessible during operation through the doors, to permit cleaning of the coils

Each fan draws depleted air from the interior of the dryer through two rows of steam-heated coils, which raises the air temperature again. The fans blow the heated air directly into the blow boxes.

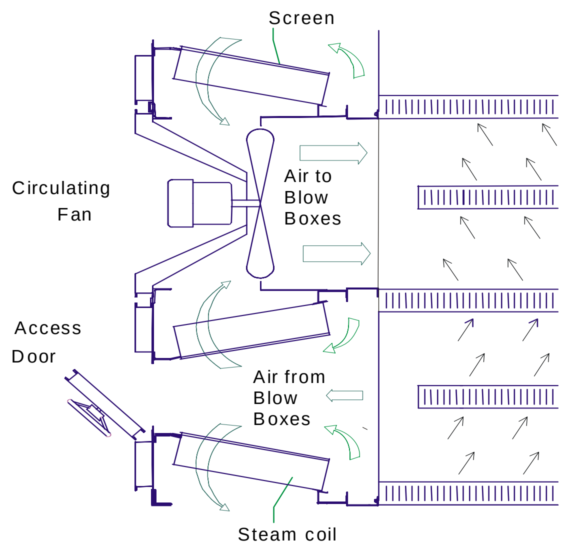

Figure 9: Plan of Coil and Fan Compartments

Plan view of a Dryer Deck

Figure 10 shows a plan view of a dryer deck, fans and coils.

Heated air is blown into the blow boxes, below the level of the plan. It then emerges through jets which impinge on the sheet. The jet orientation shown is that of a Flakt Type L dryer, pointing forward in the sheet direction and also to the side of the sheet.

Air which bleeds away from the sheet travels downward through grills between blow boxes. The purpose of the grills is to catch broke.

Heat Transfer Requirements

The bottleneck for evaporative capacity of most dryers is the transfer of heat from the fins on the coils to the circulating air. This is controlled by the fin area on the coils and by the rate of air flow past the fins. The fin area as originally supplied in

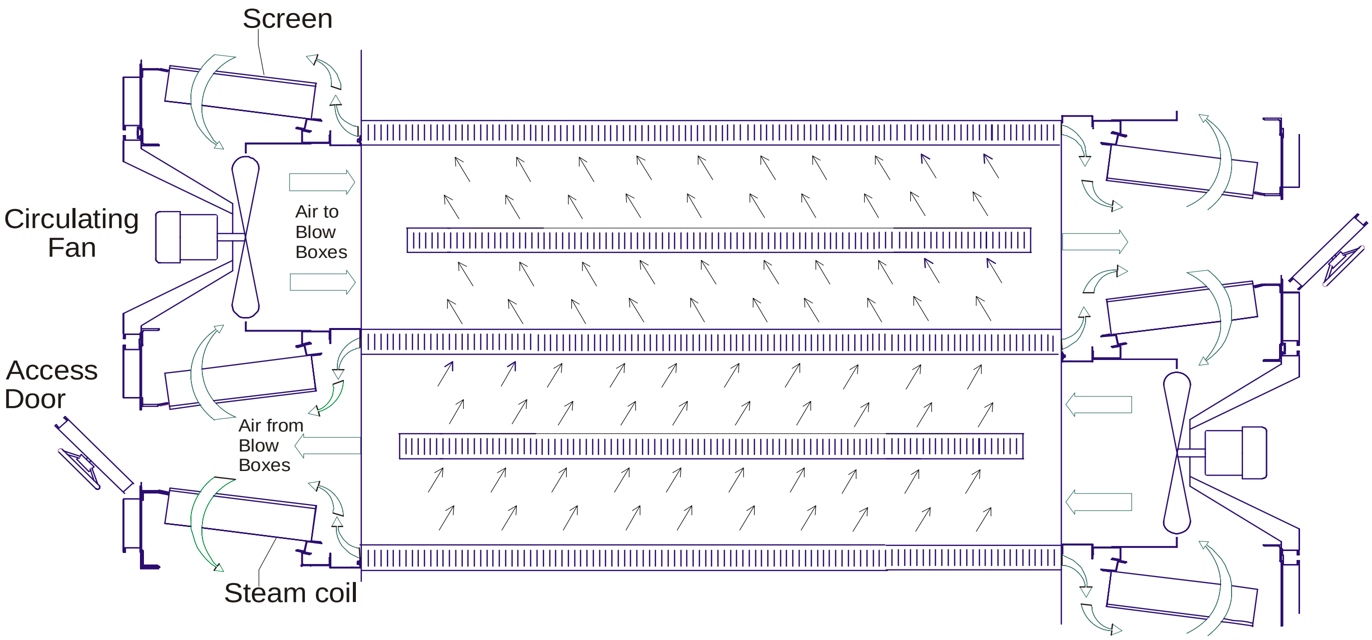

Figure 10: Plan View Of A Portion Of A Dryer Deck.

most dryers was 18 m^2 per square meter of coil face. This can be increased up to 35 m^2.

Summary of Air and Heat Flow

The quantity of air used in an airborne dryer is set by the amount of water vapour to be removed. The exhaust air should leave the dryer at about 70°C (130°F) wet bulb. The supply and exhaust fans will have been sized to meet this requirement.

The exhaust air still contains most of the heat which was brought in by the steam, in the form of hot water vapour. About 35% of this heat is recovered directly into the supply air in the air-to-air heat exchanger.

Supply air should be taken from a point of low humidity inside the machine room. After being pre-heated by the exhaust air, it is ducted under the dryer and enters the dryer through ports in the bottom of the coil compartments. In the case of Ross dryers, this air is also preheated by steam.

The air is recirculated within the dryer five to seven times by the circulating fans. It is reheated, typically by 40°C, each time it is recirculated.

Exhaust air leaves the top of the dryer, and is blown through the air-to-air heat exchangers. The cooled air is then showered with water in a wet scrubber to condense water vapour and reclaim heat.

Acknowledgements

To Leagh Farrell of Daken Enterprises who pointed out the need for a simple explanation of air flow and to both he and Stan Sather of Daken Enterprises for providing most of the information included in this paper. The author is merely the scribe, these are the experts.