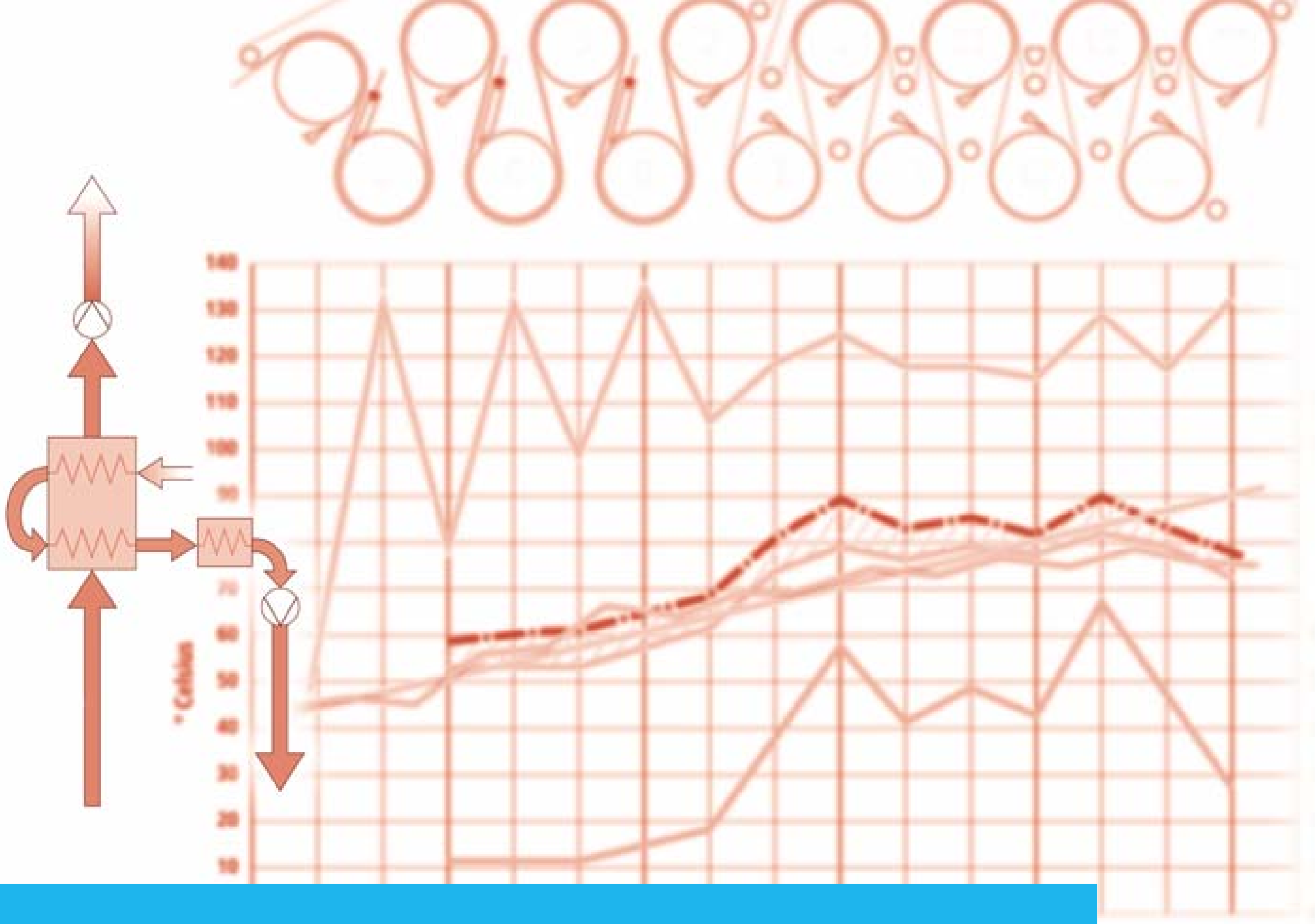

Press Release

How can the efficiency of the dryer section be increased?

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Summary of contents

Introduction

The ultimate valid criteria for the economic production of paper are: Quality – Efficiency – Cost. In this, efficiency is the link between quality and cost. This is self evident – as for the forming and press sections – and to the same extent for the dryer section.

The dryer section of the paper machine plays the following significant role in the paper and board manufacturing process: it removes from the paper or board an amount of water roughly corresponding to the weight of the finished product. In other words, the dry content of the sheet increases – depending on paper grade and the design of the forming and press section – from approx. 50% to approx. 92-98%.

The removal of the water results from both contact drying and convection drying. The physics of the process in the drying section develops in several stages:

1. Evenly distributed heating up of the sheet without evaporation
2. Evaporation of sheet surface water and transmission of the water vapour to the air as transport medium
3. (Partial) drying of the chemically-physically combined water molecules

In the dryer section the energy consumed is about 100 times more than in the forming section and about 90 times more than in the press section, to remove the same amount of water.

Owing to the physical complexity of these processes, the perfect condition and functioning of all the dryer systems and machine components is absolutely essential. Only in this way can optimal operation at the highest efficiency be guaranteed.

In many cases a production increase introduced without preliminary adjustment measures, particularly in the peripheral equipment in the dryers (i.e. less in the paper machine itself), can result after only a short time in unsatisfactory results. Reason for this: The equipment is not (any longer) dimensioned for the increased speed and capacity.

This underdimensioning very often leads to an "artificially" adapted mode of operation of the available equipment by the paper maker. Performance limits are exceeded and as a result often only a short-term compromise is achieved.

The consequences of such operation can sooner or later result in damage to the paper machine and peripheral equipment such as the steam and condensate system, the hood and air systems.

Furthermore in some dryer sections maintenance conditions, particularly of peripheral equipment, leave much to be desired, so that in addition to low production efficiency, the specific energy consumption is also increased.

For all of these reasons methods have been developed, by means of technical measurements, to evaluate the condition of the dryer section, together with steam and condensate, hood and air supply systems. Heimbach applies the most up-to-date techniques for this and presents the results for comprehensive evaluation.

In the following, the main features of dryer section analysis and hood balancing are presented.

1. Dryer section analysis

It is not our intention here to go into the theory of drying; we can leave that to the technical literature. Rather, the optimal requirements for the drying process are described – to achieve the same result by the practical route.

In a normal dryer section analysis (capacity and bottleneck analysis) the condition of the cylinders, clothing, pocket ventilation and obviously the paper/board sheet are established by means of technical measurements. For this, measurements from the front side of the machine over a range of 50-100 cm into the sheet are taken. Under certain conditions the production of CD profiles of the above are possible and even necessary.

1.1 Cylinder temperatures

The recording of cylinder temperatures provides information on the pattern of the heating curve relative to the necessary evenness of the temperature gradient in the pre- and after-dryers together with information on possible irregularities (eg. flooded cylinders). It can also be established whether unnecessary heating of inside cylinders in Slalom sections is taking place.

1.2 Sheet temperatures

Recording of sheet temperature is also necessary to avoid problems such as fibre deposits on the first few cylinders. Generally, there should be an even increase in the sheet temperatures parallel to the cylinder temperatures. Too great a difference between the two leads to fibre picking and even to sheet breaks. It is not possible to quote a maximum possible temperature difference, as this figure would be dependent on a variety of factors such as the selection of raw materials, the wet end chemistry and the required surface characteristics of the finished sheet.

The temperature difference between sheet and cylinders provides information on the effectiveness of heat transfer. Under certain circumstances too great a difference might suggest a cautious correction of the dryer fabric tension (*), a modification of the steam pressure or even a change in the dryer fabric design.

(*) In this context we refer to our TASK Information Dryer Section No.4 **Examples showing how the permeability and tension of dryer fabrics can influence paper production** – to be downloaded under: **www.heimbach.com** or obtained as a brochure by telephoning Heimbach.

For some paper grades the temperature development and the temperature level are critical for the creation of particular quality parameters. Because of all these relationships knowledge about the temperature differences between sheet and cylinders and also about the heating pattern are of great significance.

1.3 Pocket Air Conditions

In analysis of pocket air conditions the dry temperature, dew point and also the absolute water content of the air in the pockets is determined. Optimal pocket conditions can be found where the dry temperature is at least 20°C above the dew point and the absolute water content does not exceed 200g water/kg air. In this case there is enough capacity in the pockets to take up the available evaporated moisture.

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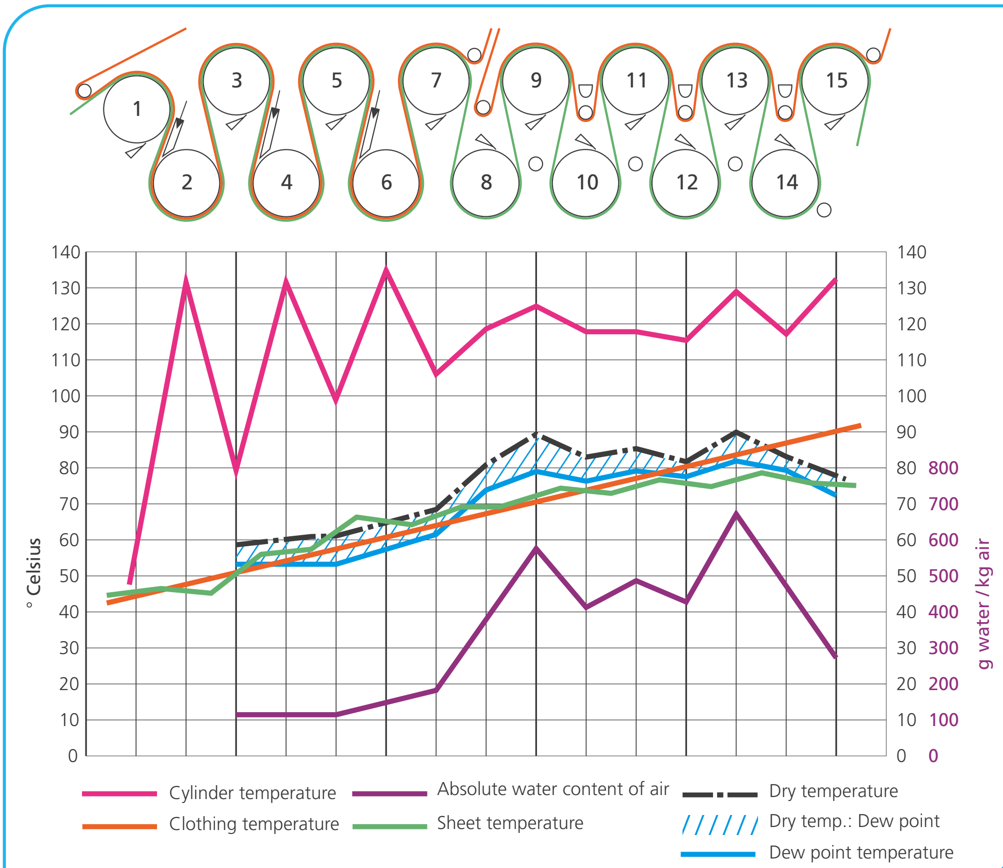
Over all, the dew point is one of the most significant factors in considering the conditions in the dryer section and the hood. In combination with the sheet temperature and/or the clothing temperature, condensation can occur under unfavourable conditions with negative results on the process – particularly if sheet temperature and/or clothing temperature drop below the dew point.

For this reason the clothing temperature on entry into the section should be obtained, since the clothing is at its coolest at this point. In conventional sections the bottom clothing particularly can suffer such a severe cooling between exit from the section to re-entry that its temperature falls below the dew point.

The following practical example (Ill. 1) shows the beginning of a dryer section. Here the absolute water content in the pockets is up to 700g water/kg air, which results in a severe raising of the dew point (up to > 80°C). Therefore the difference between the dry temperature and dew point of the air in the pockets is insufficient. As a result the additional moisture from a further production increase could no longer be absorbed.

The example shows that after the Slalom section both the sheet temperature and the clothing temperature are below the dew point.
This leads to condensate formation on the clothing and the sheet surface. Drastic losses of production can result.

Such conditions can be effectively influenced by amongst other things the condition of the hood and the air system equipment. The dryer section analysis is basically a description of the conditions. It is not able to provide information about the **causes** of the problems highlighted.



Ill.1 Case study: Temperature and moisture situation

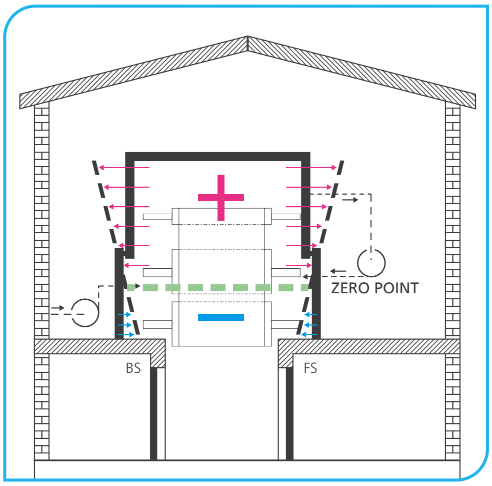
However, it offers **indications** on the direction of the necessary examinations to be carried out. In such cases then an evaluation of the hood and functioning of the installed air systems must follow.

In this context we refer to TASK Informations Dryer Section No.3 **Dryer hood: Influence of the position of the zero point on drying** and No.5 **Influencing the moisture profile by the pocket ventilation** – to be downloaded under www.heimbach.com or requested from Heimbach.

2. Consideration of air system equipment

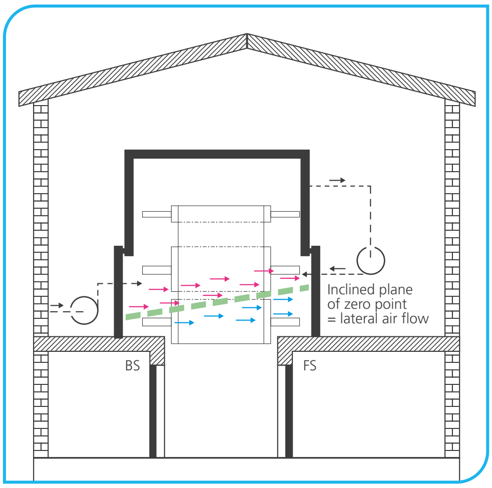
2.1 Determination of zero point position

The zero point' indicates the level above the machine floor at which the transition from underpressure to overpressure occurs in the hood. This 'zero point' which forms an imaginary 'surface' within the width and length dimensions of the hood should be at the same height at both front and drive sides of the machine (Ill. 2).



Ill.2 Position of zero point in the hood

If this is not the case, a cross-machine flow of air in the hood inevitably develops. The direction of flow is always from the side of the machine at which the zero point is lower to the side at which it is higher (Ill. 3). On modern machines the optimum height of the zero point is found between 1.8 and 2.2 m.



Ill.3 Inclined plane of zero point

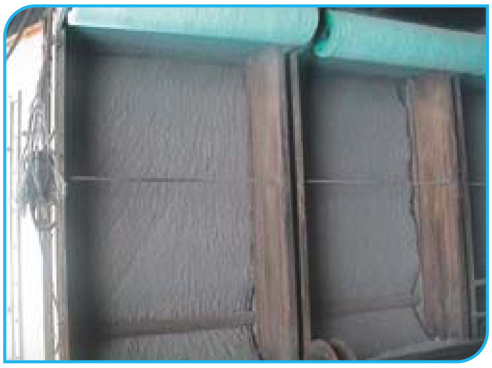
The wrong height and also a possible inclined plane of the zero point have negative effects on drying capacity, the CD moisture profile and the running characteristics of the sheet.

Details to be found in TASK Information Dryer Section No. 3 **Dryer Hood: Influence of the position of the zero point on drying.**

In order to influence the level of the zero point both the volume of air supply and the exhaust air level can be regulated. It is essential to ensure that the air supply is sufficient to take up the water vapour present, since otherwise a rise in the dew point will result. This could – as mentioned previously – produce negative results (through condensation) with regard to production efficiency and runnability (breaks / quality). The exhaust and air supply systems in the hood are normally calculated with the air supply at approx. 70% of the exhaust air volume to ensure the optimal zero point level.

Examples of negative influences on an optimum zero point level include open doors (Ill. 4) and unsealed hood doors, and also blinded air filters (Ill. 5), or leaks and corrosion points on ducting and heat exchangers (Ill. 6,7). In addition to obvious weak points, as listed above, it is also possible that faults can occur during production which are not immediately visible.

Ill.4 Open door in basement



Ill.5 Blinded air filter

Ill.6 Leaking pipework

Ill.7 Corrosion on heat exchanger

2.2 Heat exchanger balance

For the reasons mentioned above it is recommended that the operation of the heat exchangers should be thoroughly checked. This is necessary in order to obtain more precise information on the possibilities of controlling the zero point, the dry air temperature and the water balance.

In addition, checking the heat exchanger operation permits a better evaluation of energy exchange or energy loss and also the mechanical condition of the heat exchanger and its cleanliness.

In order to carry out a balancing of the heat exchangers the following information is required, which is obtained through measurements of the air flow both before and after the heat exchangers:

- Dry air temperature
- Wet air temperature
- Duct dimensions
- Air velocity in ducts

From these the following are calculated:

- Dew point
- Air volumes and air masses (dry and moist)
- Energy exchange

The balances of air volumes and air mass together with water contents both before and after the heat exchangers should be in agreement. However, uncertainties can result from the measuring technique. Differences can occur in the air flow velocities or measurement of air volume flows, since particularly on the walls of ducts frictional forces are created which reduce the air flows.

An almost laminar air flow can in some cases not be guaranteed, as depending on the measuring position insufficient calming space (for the air flow) is available after a pipe bend. Therefore it is necessary to accept a certain tolerance range with the volume and mass balances. Finally, it can be a case of trends from which appropriate measures have to be drawn.

It must be said that the process of heat exchanger balancing without the knowledge and inclusion of the calculated (by the manufacturer) efficiency levels of the heat exchangers the energy balance cannot be worked out.

Reason: For one thing there are radiation losses and also the heat exchangers are almost never in a suitably clean condition. The following is a schematic presentation of an exhaust and air supply system with relevant measuring positions and the resulting values and calculations (Ill. 8).

In this measuring example there are a number of points of interest:

- In the fresh air range the mass of dry air after the heat exchanger is reduced by approx. 4750 kg/h and that of the moist air by approx. 4600kg/h.

- In the exhaust range the mass of dry air after the heat exchanger is increased by approx. 3800 kg/h, and that of the moist air by approx. 1750 kg/h.

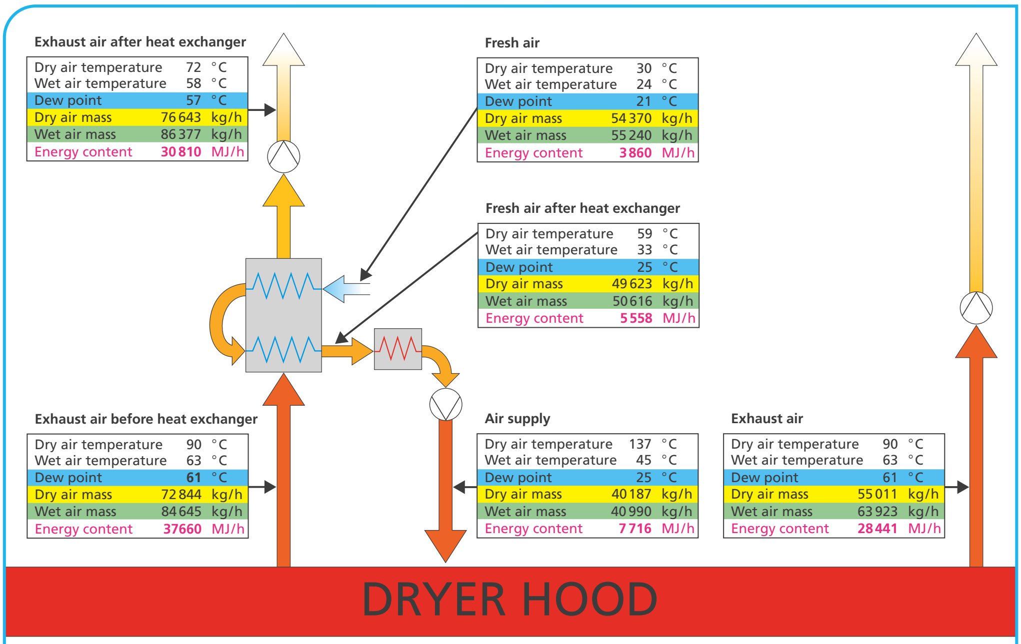
Conclusion: Even when the balance (for reason of the previously mentioned uncertainties) does not increase in the moist air range, the probability of leakage in the heat exchangers and adulteration can be assumed.

- Between the measuring points before the steam/air heat exchanger and after the ventilator in the air supply zone the air masses – moist and dry – are each reduced by approx. 9500 kg/h.

Conclusion: In this area a leak is present through which approx. 20% of the air supply is escaping. The result is an inadequate air supply volume and also possible problems with the zero point and the dew point in the hood.

- The dew point of the exhaust air on the way to the heat exchanger is in excess of 60°C – it should be **less than** 60°C!

Conclusion: Depending on the insulation of the ducting the danger of condensation forming and running back into the hood is significantly



The above diagram is a much simplified schematic layout of a very complex series of data.

Ill.8 Air system layout, determination of values, measuring points
Case study: Leakage in a heat exchanger

increased. In this case the air supply / exhaust systems of the whole hood should be urgently examined in more detail.

Normally, the air supply volume should amount to 70% of the exhaust volume. In this case it is 31% maximum – taking account in the calculation that there is a second exhaust zone. Also in this zone the exhaust will be given off to atmosphere without any heat recovery. This means additionally an enormous energy loss.
In the exhaust zone the following points are to be considered:

__ The dew point of the hood exhaust should generally be **less than** 60°C, as otherwise there is the risk of condensate build up in the ducting.

__ The exhaust **after** the heat exchanger should be substantially cooler than **before** it. If this is not the case, blinding of the heat exchanger or even damage to it can be assumed.

__ The dew point of the exhaust air should be below the dew point of the outside air. Otherwise abrupt condensation of the exhaust moisture in the outside air results and it begins to "rain". If this precipitation were to fall on the building, water damage could result.

__ The required exhaust volume should be compared with the specifications of the fan. In the event of significant differences or values outside the manufacturer's tolerances – and the zero point in the hood being too low, power consumption, revolutions and fan blades should be checked together with ducting to the fan.

For the air supply area there are also some critical points to be considered which (naturally) are the opposite of those applying to the exhaust area.

__ The air supply **after** the air/air heat exchanger must be substantially warmer than **before** it. If this is not the case blinding is probably present.

__ If the air supply after the air/air heat exchanger is not only warmer but also moister, the heat exchanger is probably damaged, as the moist air from the exhaust area is mixing with fresh air.

__ After the heat exchangers the air supply temperature should not be higher than 120°C. Higher values indicate higher energy costs, without significantly increasing the drying capacity of the air.

__ Temperatures below 110°C after the heat exchangers conceal the risk of cooling the air supply in the pockets below 100°C and with it an enormous reduction in water take up capacity.

The energy values shown up in the balance can be used to calculate the energy loss. Also, for example, calculations of savings for maintenance work or investments can be carried out.

In order to obtain a really conclusive view of the total air situation – and with it a usable evaluation of the hood in practical production and energy utilisation terms, it is also recommended for the analysis of the dryer section air supply equipment that a hood balance is worked out.

3. Hood balance

In the balancing of a dryer hood the moisture volume to be removed is calculated. To ensure its removal an appropriate air volume will be required. This air volume based on experience is around 10kg dry air per 1 kg water. Evaporation rates differ depending on paper grade and production volume. Therefore a hood balance should be carried out for the production level requiring the highest evaporation rates in the dryers.

The resulting moisture volume is determined by three factors:

__ Moisture content of the sheet entering the dryer section

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- Moisture content of the sheet at the end of the dryer section
- Moisture content of the hood air supply

In order to calculate the necessary dry air mass only the moisture volume created by the sheet is applied.

From the dry content of the sheet entering the dryers, its surface related mass, the sheet width and the speed, the moisture volume introduced into the hood is established. Similarly, at the end of the dryer section, the removed moisture volume is established.

The difference between the two values is the moisture volume to be removed from the hood by the air systems. If the machine has a size press the additionally introduced moisture volume has to be taken into account.

In the example shown (Ill. 9) 21 689 kg/h moisture are removed in the pre-dryers. According to the above mentioned calculation based on experience 216 890 kg/h dry air would be necessary for the removal of this moisture. The measured dry air mass was in fact 230 356 kg/h. Therefore the exhaust air mass is within the good range.

However, for the air supply volume, which should be around 70% of the removed air volume (i.e. 151 822 kg/h), a figure of only 31 878 kg/h was measured. The air supply volume is therefore well below the recommended figure.

In a subsequently necessary heat exchanger balance the reasons for this poor performance were established: blinding, damage, fan problems etc.

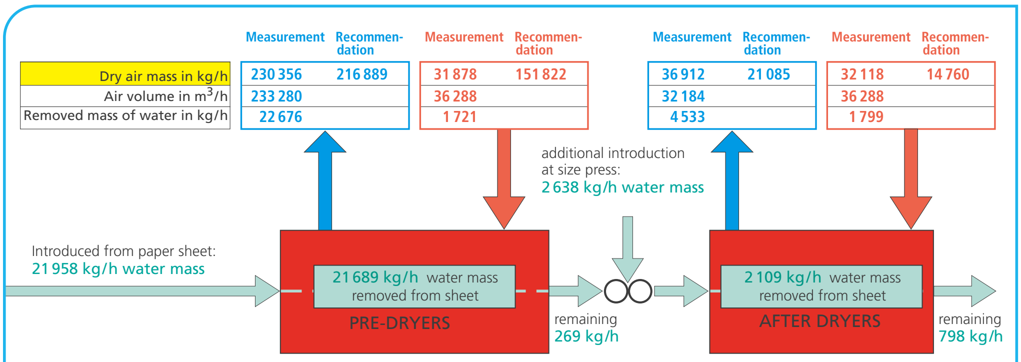
Because of the very low air supply volume it can be assumed that the zero point in the hood is in a range which is much too high. As a result a large amount of outside air will be pulled into the hood.

This will cause a further drop in the temperature of the air in the hood. The air in the hood is then significantly less able to take up the evaporation. In all probability condensation inside the hood will result.

In the after dryers on the other hand the air volumes are ample, but the air volume ratios are not optimally regulated. Here it should be attempted to reduce the air supply volume by means of dampers. Too high an air supply volume causes too low a zero point and thereby too high an overpressure.

It can lead to the outflow of moist air from the slot in the hood, through which the sheet enters and which is in the overpressure zone. Hot moist air then condenses outside the hood on "cold" machine parts. As a result water drops can fall on to the sheet causing quality problems or even increased breaks.

Additionally, because of the too low zero point the air tends to flow into the pockets from outside with



The above diagram is a much simplified schematic layout of a very complex series of data.

Ill.9 Case study: Air and water volume situation the result that the moisture removal is no longer guaranteed. Thereby irregular moisture profiles can result (see TASK Information Dryer Section No. 5 **Influencing the moisture profile by the pocket ventilation).**

Summary

Dryer section analysis, evaluation of air supply systems and hood balancing provide the paper maker with usable information on possible weaknesses in the drying process. Causes of quality problems and poor runnability can be found to lie in the purely mechanical areas and in the air supply systems of the hood.

Information on the temperatures of dryer cylinders, the sheet and the clothing together with measurements of exhaust air, supplied air and air in the pockets are necessary in order to discover the causes of problems. It is also important to establish the air flow volumes in order to evaluate their balance.

Incorrect air volume ratios negatively influence the air conditions in the hood and push the dew point and zero point in unfavourable directions. Quality problems and deteriorating running characteristics are often the result.

For all these reasons all process-relevant and energy conditions in the dryer section and the hood should be checked at regular intervals. Such intervals could be:

- Before and after rebuilds
- After other changes designed to increase production
- In the event of quality problems with unknown causes
- Generally for checking energy consumption

Dryer section analysis, evaluation of air systems and hood balancing should form the basis for total process optimisation in area of the dryer section – and can in some cases even assist in discovering the source of problems arising earlier in the production process.

For further information or questions please contact the dryer section specialists of the Heimbach Group.

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