# dryer part of the paper machine and few aspects of drying

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*Cellulose has good affinity for moisture. Drying of paper is inevitable for the removal of water contained in the paper web. The drying of paper follows three stages:—the warm-up period, the constant drying period and the falling rate period. Dryer felt, the choosing of felt material, quality, type etc. are factors of importance. Cotton felt, synthetic felt, needled felt—all have their distinctive role and value in paped drying. The drying rate and steam consumption differs with different felt material. Felt tension, arrangement of felt in dryer groups, draw speed and paper quality come in the consideration of the papermaker. High velocity dryer with its various features is really challenging to-day, and the modern methods speak for specific advantages over the conventional ones.*

Paper is a hydrophilic substance, and hence it is virtually impossible to dry wet paper by mechanical means. When the paper enters the dryer section, it contains a moisture %age in between 60 and 70. Actual drying takes place by guiding the sheet over steam heated dryers in order to evaporate the water contained in the web, coming from the wet end.. contained in the web, coming from the wet end.

*Cylinder drum drying*:

A typical dryer drum on a paper machine is five feet in diameter, designed for a steam pressure of 40 to 100 p.s.i, and covered on 50-65% of its circumference by an endless felt arranged to travel with the rotating cylinder. Such an arrangement is shown in Fig. 1.

The sheet is rapidly heated at it passes over the cylinders. At 80-85° C sheet temperature, evaporation starts and the temperature rise is retarded. As the process of drying proceeds, the steam in the dryers condenser and the resultant hot water must be removed from the dryer as fast as it condenses. Tremendous quantity of water evaporated from the sheet creates moisture laden air, which must also be removed with a view to preventing reabsorption into the web and providing working condition in the machine room itself, which, in the meanwhile, becomes surcharged with vapour transforming into fog and condensation in the form of rain like drops all around.

*Drying principle* :

The drying of paper, whether it takes place in conventional dryers or in a cylinder machine, passes through three distinct stages :—

(1). The warm up period,
(2). The constant drying rate period, and
(3). The falling rate period

During the first period, the paper enters the dryer and the temperature of the sheet is raised, to approximately the wet bulb temperature of the dryer section. Normally, the period is quite short, and very little evaporation takes place from the sheet. Once the sheet attains the wet bulb temperature, it enters the constant drying rate zone. It is here there is adequate and free moisture on the surface of the sheet, which results in a constant evaporation rate. During this period, the sheet temperature remains at the wet bulb temperature. The third and final stage of drying takes place, when there is no adequate and free moisture on the surface of the sheet. The drying rate, at this stage, is controlled by the diffusion of moisture from within the pulp sheet to the outer surface. During this period, the sheet temperature rises quickly from the wet bulb temperature, and if the drying process is carried out long enough, the sheet temperature attains the dry bulb temperature of the surrounding air. Since the specific evaporation is much less in the falling rate period, the length of dryer increases very rapidly.

*The Sirpur Paper Mills Ltd, Sirpur-Kaghaznagar.

period the length of a dryer increases very rapidly, as the leaving moisture of the sheet is decreased past 90% bone dry.

*Dryer felts* :

The purpose of the use of a felt is two-fold :— for increasing the evaporation rate and for reducing the over-all cost of drying. Choosing of particular quality and type felt is very essential for the following reasons :—

(1). Resistance to wearing,
(2). Lack of shredding fibers,
(3). Ease of guiding,
(4). Absence of mark onfibers, and
(5). Good dimensional stability.

*Woollen felts* :

Woollen felts are used in Europe, when making fine papers, requiring a smooth finish on the felt side. Woollen felts are favoured under acid conditions. Woollen felts on the dryer end endure for 12-18 months, but eventually, the heated surface of the felt chars and starts to dust. In a humid atmosphere, they may last only 5-7 months. The shinkage of the woollen felt varies much, the edges, in particular, behaving quite differently.

*Cotton Felt* :

Cotton is the most popular and the main ingredient of dryer felt. The cotton felts are mainly used for the following reasons :— they are cheap, possessing good dimensional stability and good strength. It has good resistance to abrasion, although it gives a coarse surface. The present practice is to reinforce the cotton with 12% polyster fibre to increase the strength. In the wet end dryers, chemically impregnated asbestos felts or incorporated asbestos threaded felts are used. The asbestos absorbs the sulphuric acid, if it sometimes transpires in liquid form at the dryers, and that protects the cotton yarn. Asbestos makes the felt dimensionally very stable in the cross direction.

*Synthetic felt* :

Where temperature and humidity are high (i.e., in the second top dryer group), a Synthetic felt may be used. High felt tension in dry atmosphere requires a ploy ester fiber, which has low stretch, high strength, low tear and good heat resistance in dry atmosphere. Of course, the cost, being double the that of cotton, counts. Woollen felts shrinks, as they dry, while cotton felt strech, synthetic felts maintain their dimension.

*Needled Felt* :

Needled felts are made from a base fabric of synthetic fibers into which a blend of loosely felted synthetic and natural fiber is needled by a synthetic technique. The result is a felt with smooth, non-marking surface, which is comparable to that of woollen. The needling creates capillaries running through the thickness of the felt effecting a high steam permeability.

*Plastic fabrics* :

Plastic fabrics woven of mono filaments of, for example, polyamide or polyester are coming in use as dryer felts on many paper machines. Compared to all synthetic felts, plastic fabrics are more permeable to steam and humidity. The specific surface of the mono filaments is much lower than that of the felt fibers; this factor accounts for the low deterioration.

*Drying rate* :

It is expressed as lbs. of water removed per sq. ft. of dryer surface per hour. Some authoritative experiments have been conducted, and the drying rate with different materials can be summed up as:

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| Werecloth and linen | — | highest dring rate |
| Wool and cotton | — | identical |
| Cotton and asbestos | — | slightly worse |
| Wire cloth | — | good at the initial stage, when the web is damp, but linen is good at the later stage. |

*Steam consumption & Felt*:

The steam consumption is related to water removal from the web, which, in turn, is related to the material of the felt. Heavy wool consumes quite a good quantity of steam, whereas felt made of light wool needs much less quantity. This means that thin woollen felt has higher rate of water removal.

*Felt drying equipments*:

Felt should be kept dry, specially those natural fiber-based ones, as they pass over the first few cylinders. If the felt drying capacity is inadequate, a wet streak in the sheet serves to wet the felt and makes it less permeable to steam, thus reducing the rate of evaporation from the sheet at the wet streak. The cause of uneven moisture is far more common than is realised.

The felt drying equipments are :

(a) Steam heated cylinders of small diameter, temperature with a provision for pressure so as to keep high temperature in the surface of the cylinder. In modern paper machines, a felt ratio (felt dryer area to paper dryer area) of 0.2 to 0.25 is common. At the wet end, it may be as high as 1.3, while dry end groups may lack felt dryers altogether.

(b) Hot air blown through nozzles, and

(c) Rotating perforated roll, to which suction is applied for drawing out the moist air through the felt.

*Felt tension and arrangement of dryers* :

Adequate tension can often be applied to the web to achieve the close heat contact with the cylinders, and that is the primary function of the felt to assist that part of the process. Except for the dry felts covering the first few cylinders, there seems to be no reason whatsoever to apply a tension, which is by itself heavy. The greater the tension, the more the felt is likely to distort or crease under adverse conditions of moisture change, as occasionally occurs opposite a wet streak or at a break. Tension should be even across the machine in order to reduce the chance of creating an uneven drying rate in different parts of the web.

The wrap of the felt over the cylinders should be great. The two dryer felts over the first few cylinders are the most critical and they must cope up with the maximum amount of water removal. These should, therefore, be short and cover not more than four or five cylinders each, preferably less.

*Drying & Paper Quality*:

Paper shrinks during drying, and the reason for this can be traced back to the shrinkage of the fiber shrinks 1-2% in the axial direction and 20-30% in the ransverse direction. When the cellulose fiber is dried, his shrinkage of the compenents also results in the shrinkage of the whole. The sheet should be kept tout throughout the drying process for greater drying efficiency and to prevent the wet sheet from wrinkink and splitting, which can lead to cuts, while the sheet goes through the cylinder stacks.

To keep the sheet tout just below the breaking point, provision must be made to have each successive dryer section running at a slightly higer speed than the foregoing section.

Apparently, shrinkage in the machine direction best restrained by a combination of tight draws and slack felts while in the cross direction slack draws and tight felts are more efficient in this respect. This is shown in Fig. 2 & 3.

*Tensile strength* :

If the sheet is restrained from shrinking along one direction, the tendency to shrink along the other increases and vice versa. As a rule, shrinkage occurs between 60-70% at sheet dryness. Tensile strength increases with a tightening of the draws, when the water to solid ratio is 1.2 to 2. This is because of more uniform stress distribution between the fiber bonds. This increase, however, is only upto a maximum, after which the tensile strength drops again due to rupture of the fiber bonds.

*Smoothness of sheet*

Rapid drying of a sheet with low initial dryness produces a rougher surface than obtained from slow drying of a sheet, entering the dryers at higher dryness. Possible explanation of this is the smoothening effect of more efficient wet pressing and of laying of the sheet against a larger number of drums before the surface hardens (if the first few cylinders are in low temperature). Higher thermo-plasticity of the paper surface during slow drying is due to the capillary flow of water to the surface so that it can keep pace with the evaporation from it. Breaker stacks installed in dryer

section improves smoothness, since the paper is most cosily glazed, when hot and moist.

*Sizing of paper* :

Good sizing calls for a low dryer temperature at the wet end and a slow temperature rise progressively towards the dryer end. At higher speed, the size can withstand a higher temperature, as the fusing time will be shorter. At low speed, good sizing may demand a reduced temperature on the last dryer after the size has been fused.
Rapid drying sometimes causes a migration of size particles with the water toward the heated side of the sheet. *Two-sided sizing* is necessarily the result. In addition, non-uniformity drying across the machine causes sizing variations.

*High Velocity*

The dryer is essentially a sheet metal chamber that fits in under, or over and partially around a dryer drum. The dryer discharges air against the travelling web through slots at velocities upto 15000 c.f.m. and temperature upto 315°F. The dryer is divided by vertical partitions into six seuarate compartments, each serviced progressively by six supply ducts, which connects the moist air supply with the dryer. Different velocities can be maintained at different web locations, if moisture content varies across the sheet itself. The high velocities as well as high temperature can be controlled by means of a temperature Controller. The return air is drawn and reused after heating. This equipment can be installed without disturbing the rewinders and the other equipments. besides, it costs less.

The dryers serve to control both the temperature and the ratio between water migration to the top and bottom side of the sheet. Better sizing results because of a higher sheet temperature at the critical moisture level.

*Drying under vacuum* :

Minton dryer completely encloses a conventional dryer section under a cast iron hood built to withstand high vacuum (upto even 26″). The sheets enter and leave under scaling nips. The sheet moisture is boiled off at 120°F. The thermal efficiency is claimed to be 90% with no radiation loss of heat. Due to its low temperature, good sizing is not obtained, while soft and bulky products are obtained. This type of dryer is successful for drying of pulp and newsprint.

*Free Air Drying* :

It is a new technique at the pilot plant stage of development. It is drying of paper without the use of cylinder drums. It is made possible by the development of the 'blow box' for ejecting and withdrawing drying air; with this device, a web of paper, floating along the top of the box, is held by air jets against the box without actually contacting it. The sheet is sucked against the box by the ejector effect of air jets parallel to the box top. The suction keeps the sheet flat, but it does not restrict shrinkage. Sizing and surface smoothness pose a problem in this type of drying.

*Fluidized bed drying* :

It is as yet in the preliminary stage of development. Basically, the web is fed up through a slot into the bottom of the fluidized bed. Possible advantages are high thermal efficiency, low space requirements and new paper behaviour, particularly with respect to shrinkage and porosity.

*Dielectric heating* :
In this process, high frequency electrical energy is dissipated within the sheet. Here the heatng cost is unfortunately much. This method has been suggested for rapid diversion of moisture, trapped in the centre of thick paper or board.

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