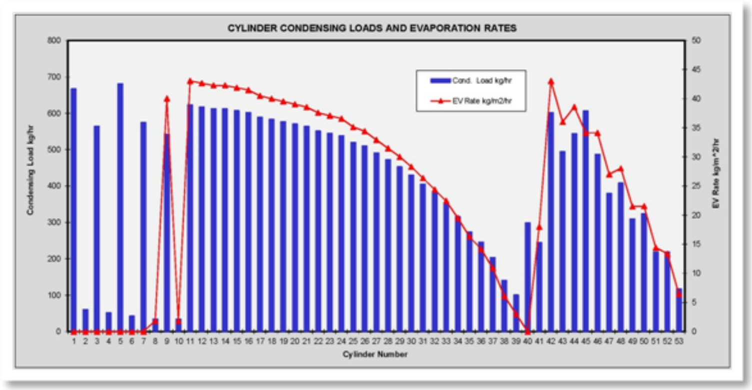
# Paper Machines and Yankees

## Paper Machines – System Design




The first step to design a system is to develop a model of the performance of the system. If it is an existing system then the initial model will be for the system as it is running now. The system is then compared with known norms for the type of product being produced. The next step is to develop a model based on how the machine should be running.

The above graph is an example of a Fine Paper machine running at over 900 m/min. The blue bars represent the condensing load in each cylinder and the red line the evaporation rate from each cylinder. As can be seen from the graph there is a big difference depending upon the position of the cylinder.

Some of the system design and operation that leads to such a profile are:

1. The sheet enters the dryer section relatively cold (40 to 50$^{o}$C) and needs to be warmed up so in the first section of cylinders there is no evaporation.

2. Because the sheet is relatively cold the first cylinders have a very high condensing load (large temperature difference between the sheet and the steam).

3. The sheet has to be warmed slowly to prevent 'picking'/damage to the sheet surface

4. There is often a uni-run on at least the first drive section so the condensing load in the top cylinders is much higher than the bottom cylinders.

5. Fine paper machines often have a size press/coater part way down the machine and the sheet is dried to a low moisture content in the Pre-dryers. As such the condensing loads and evaporation rates drop off significantly in the last few dryers.

6. After the size-press/coater the sheet needs to be warmed again slowly to prevent contamination of the cylinders.

7. There is often a need for curl correction by have a difference in temperature between the top and bottom cylinders which can be seen by the jaw shaped evaporation rate line.

8. Sometimes a moisture profiling spray is used, which adds water to the sheet to correct poor cross machine moisture profile. In this example it is shown at cylinder 45 which has a relatively higher condensing rate due to the cooling effect of the profiling water.

The above is just an example of the typical design parameters that have to be considered for the steam and condensate system. So before considering any issues such as number of steam groups or use of thermocompressors or cascade, all of the various machine and operating parameters need to be modelled on a cylinder by cylinder basis.

Once the profile has been established for the machine and the basic layout in terms of number of cylinders in each group, use of thermocompressors or cascade (or both), then the detail design can be applied to calculate siphon type and sizes, line sizes, specifications of control valves, pumps, tanks, etc.

**Siphon Types**

There are four main categories of siphons:

1. Low speed stationary siphons – usually a bent tube – for speeds in the range of 0-200 m/min
2. Low speed rotary siphons – usually with a scoop – for speeds between 200 and 500 m/min
3. High speed rotary siphons – usually with a 360$^{o}$ shoe – for speeds between 500 and 1000 m/min
4. High speed stationary siphons – a highly designed/strong structure – from 0 to 1800+ m/min

It maybe that a machine will have more than one type e.g. high speed rotary and high speed stationary but there should never be two types in the same steam group. The correct selection of the siphon and the siphon size is fundamental to the final success of the steam and condensate system operation. PES manufactures their own rotary siphons but will buy the High Speed Stationary siphons when needed. Not all machines are able to utilize the benefits of the High Speed Stationary Siphon or justify the significantly higher capital cost.

**Velocity Control Vs. Differential Control**

One issue that is discussed is the option of Velocity Flow Control or Differential Control. In most cases PES supports Velocity Flow Control however it often the case that a PES system will have at least a few cylinders on Differential Control when there are only one or two cylinders in a group.

Velocity Flow Control maintains a fixed velocity of the blow through steam in the siphons by modulating the differential across the steam group. This ensures that the optimum differential is maintained at all times which is important not to create moisture profile problems, flooding of cylinders, poor energy efficiency and erosion of siphons. So for the majority of the cases Velocity Flow Control is superior.

PES normally only use Differential Control when there are only one or two cylinders in the group, usually just after the press or coater and the higher capital cost associated with Velocity Flow Control cannot be justified.

**Yankee Systems**

Although the Yankee cylinder is just one cylinder, the size and velocity of modern Yankees make the design of the steam system a challenge. The large size and high velocity mean that it is necessary to use a high blow through steam rate which can be as high as 100% of the condensing load. The high flow rate couple with the large centrifugal forces mean that the differential required to prevent flooding is much higher than on a multicylinder machine.

Thermocompressors are the only real option for a Yankee dryer but the challenge is to design a unit that generates sufficient differential pressure for the blow through steam rate required. There is a limitation since the maximum flow through the thermocompressor is limited by the condensing rate of the cylinder. The pressure ratio between the high pressure motive steam and the cylinder pressure is the key to the successful operation of the thermocompressor and the objective is to be able to circulate the entire blow through steam, but still require a little steam for the Yankee pressure control valve.

There is only one good solution for the blow through steam control and that is Velocity Flow Control but it is better to operate the thermocompressor from the pressure control loop and have a separate control valve for the blow through steam. This ensures greater stability for the system since modulating the thermocompressor will affect both, the Yankee pressure and blow through steam flow at the same time, not ideal.

The other area that is a key to the successful operation of a Yankee steam system is the design of the Yankee siphons. If the Yankee is ribbed then the siphons need have sufficient straws with sufficient diameter to ensure the correct blow through steam rate at the required velocity. The siphon riser then needs to be sized to match the straw velocity to prevent separation and slugging of the condensate.

As well as designing the steam and condensate systems PES are able to supply correctly designed siphons that would be designed to optimize the condensate removal from the Yankee. There are few companies worldwide who can supply Yankee siphons outside of the original Yankee manufacturers.