Energy Efficient Systems for Drying Coated Paper

CERAMIC GAS INFRA RED SYSTEMS

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COMPARISON OF 3 DRYING METHODS

Infra-red is non-contacting drying and heats by

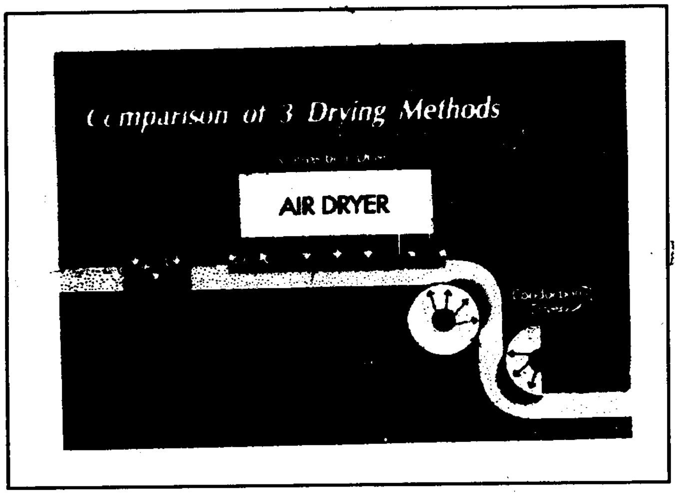


Fig. 1

means of radiation from within the coat or paper.

- Air drying is also non-contacting web but heats at the surface of the coat or paper surface by means of convection.

- Cylinders are a contact drying method and start to heat the coat or paper surface by means of conduction.

A good approximation of drying capacity is:

- 1 meter in the Machine Direction of a Solaronics gas infra-red system is equivalent to the drying capacity of

3.5 meters of an air drying air flotation system

or

1.5 cylinders of 1.5 meters in diameter.

INFRA-RED DRYING
Comparison Electric/Solaronics

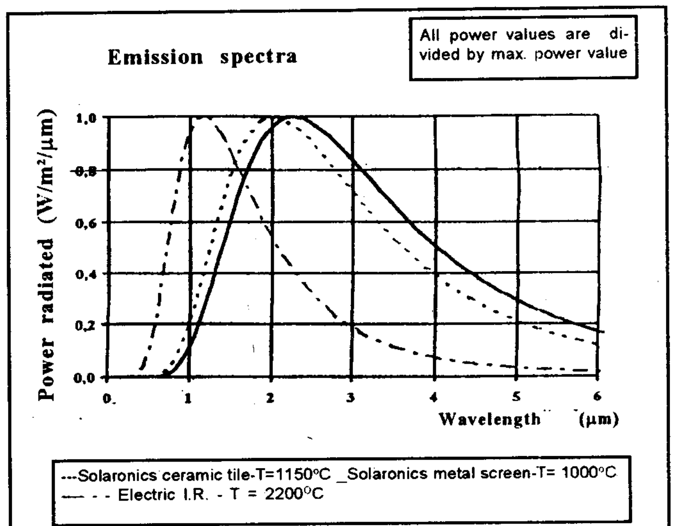
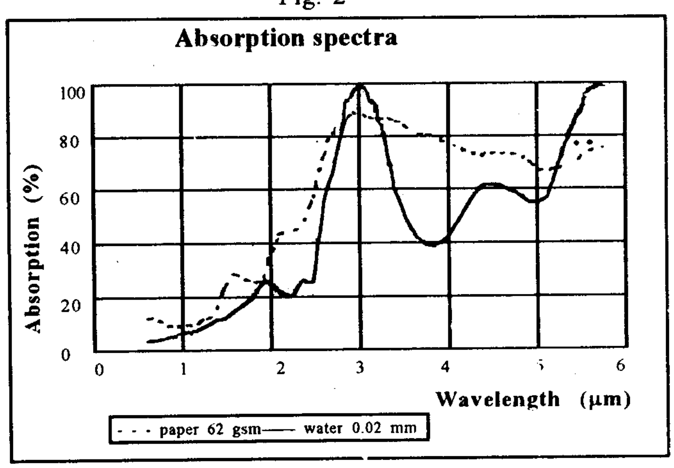


Fig. 2



- Depending upon the emitter operating temperature the infra-red radiation spectrum varies

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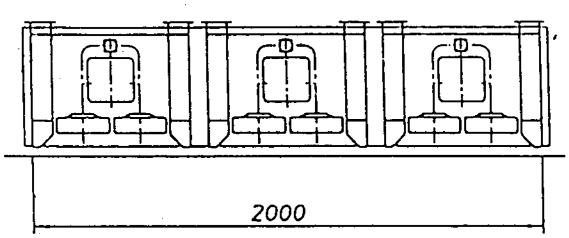
(According to both Wien's Law + Stefan and Boltxman's Law)

An electric infra-red with a common filament temperature of 2200°C will have, for the same power input, a higher radiation output than a gas infra-red system operating at a lower temperature (below 1000° C for metal emitters, 1150° C for the compact ceramic tile, Solaronics emitter).

However, because of the shorter wavelength (1 μm peak wavelength for electric infra-red versus above 2 μm for Solaronics) the absorption of energy by moist paper ("coupled" infra-red radiation) is by far lower with electric infra-red and the higher "output" is not well absorbed by the sheet.

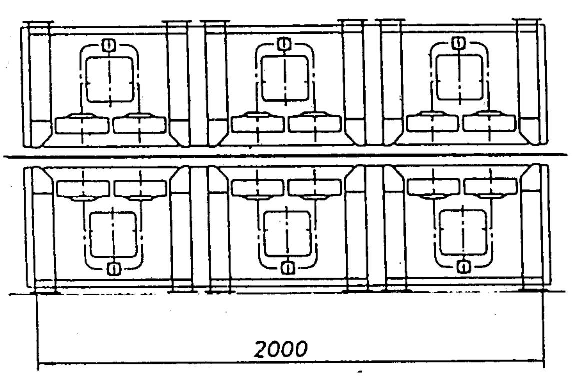
Typically the efficiency of electric IR systems is around 30% (ratio: energy absorbed by the web/ energy consumed). This compares with up to 60% for Solaronics gas IR systems.

TABLE 1



1 row = 25 kW/m to the web
12 rows = 300 kW/m to the web = 150 kW/m²
Free Water 0.641 kW .h to the web/kg of water = 234 kg/h/m²
not face to face application
(excluding heat-up and bonded water).

TABLE 2



1 row = 30 kW/m to the web
6 rows = 180 kW/m to the web = 90 kW/m²
Free Water 0.641 kW .h to the web/kg of water
= 140 kg/h/m²
not face to face application
(excluding heat-up and bonded water).

Moreover, the cost of energy is by far lower for gas than for electricity.

Combining these 2 economical factors the savings over the course of one year might represent the original capital investment of an infra-red system.

Radiation/convection ratio of an infra-red emitter. Energy recovery

Solaronics infra-red systems have a very high ratio radiation/convection which is very important for quality reasons.

This is achieved thanks to emitter design and optimised heat exchange of flue gases exiting the infra-red to avoid drying the surface of the coat (skinning) with flue gases (long life high temperature screens in front of the cermic emitters heated up to 1000° C).

The distance emitter/web is optimised for radiation homogeneity.

Drying with high temperature flue gas will artificially increase the efficiency but is detrimental to quality. Solaronics has also uniquely studied energy recovery:

- at the back of the emitters,
- in the flue gases (air recirculation system)
- within evaporated water combined with flue gas (exhaust air recovered in air turns, air dryers, heat exchangers, etc.)

Quality

Mass transfer

If the evaporation is properly conducted the coat temperature will remain constant and in a range of 76/85°C. (in the evaporation phase).

Solaronics **(Fig. 3)** has an air recirculation system for each 2 row of emitters (620 mm in M.D.)

The air scrubes the moisture laden boundary layer by means of a Coanda Bernouilli type nozzle (which also serves to stabilise light weight webs, over the full width of the sheet).

The temperature range of the air blown on to the sheet can be regulated and a temperature set point made (usually around 100/120° C).

There is of course enough air blown on to the sheet to realise a high rate of mass transfer.

Drying inequality

Solaronics heats the coat from within (using

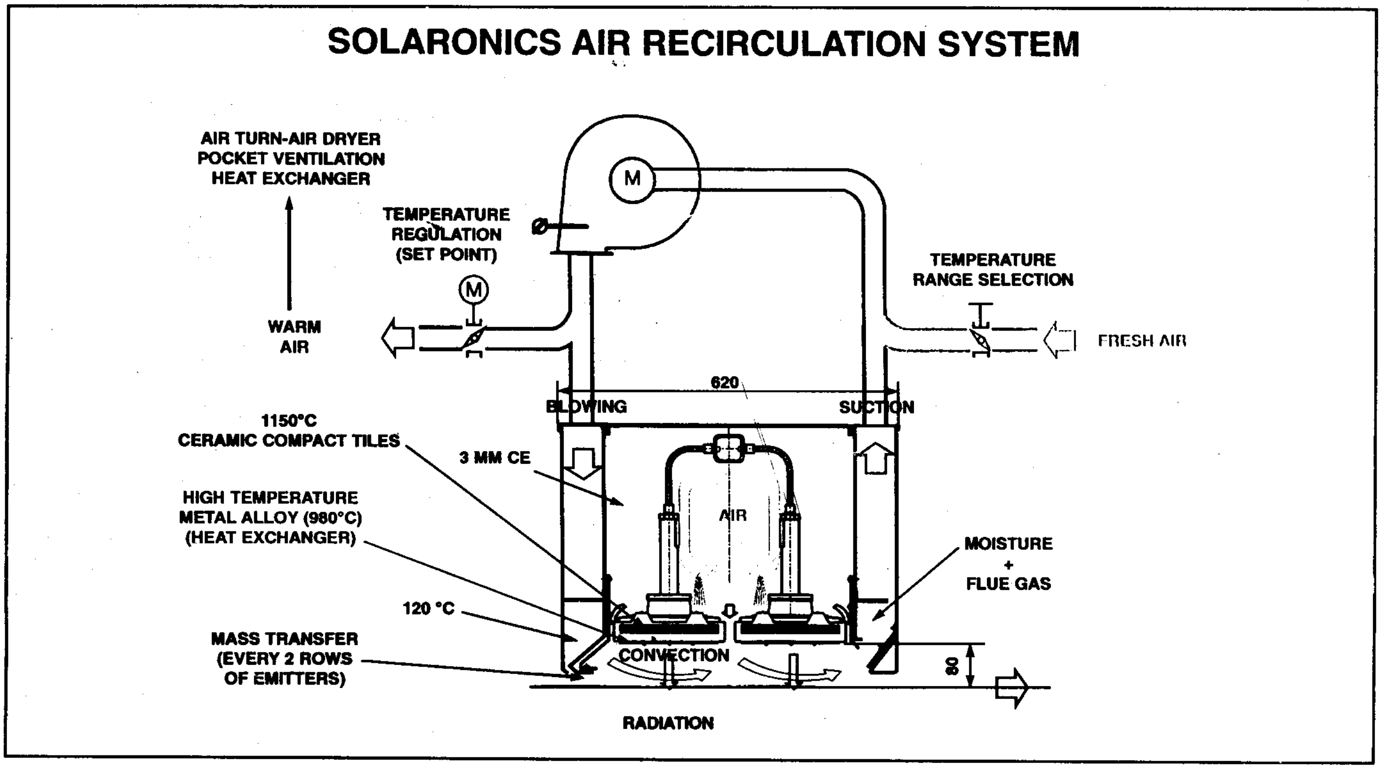


Fig. 3

the optimum wavelength spectrum for absorption) with a high power density.

Mass transfer allows for excellent temperature control of coat surface.

- Electric infra-red will mainly heat the base paper (or even pass straight through light weight sheets). This will lead to open paper fibre pores and increases in the uneven dewatering from coat colour into base paper.

- 100% convection air drying (air dryers) overheats the coat surface and then dries by conduction (migration of binder to the coat surface may occur because of the temperature gradient)

DRYING STRATEGY WITH IR

A sheet of paper consists of a matrix of cellulose fibres (millimetres in length), which are orientated either side to side or one-across-the-other, in a random matrix, which has a multiplicity of voids (which can be evaluated in tenths of millimetres). Even when mechanically smoothed by a calendar (either steel, soft, super), this basic structure remains.

Sizing applied to the surface of the sheet will re-enforce the inter-fibre bond in order to achieve resistance to picking from tacky, glossy inks.

Sizing alone, however, is not sufficient to satisfy a more demanding printing market where ever increasing consideration must be given to: colours, fine screens, fine dots, sharp contrast, glossy inks, varnish hold-out, etc. Current targets of surface finish cannot be achieved by size alone and an application of lightweight pigment is required. The fibre structure is coarse when compared to a pigmenting film. Pigment dimensions are measured in microns and a film coated pigment layer of approximately 10 gsm is approximately ten microns in thickness.

With the ever escalating demand for machine speed increase, the industry has switched to metering equipment such as gate roll size presses and later, high speed metering devices for **film pigmenting** applications.

How can the paper maker achieve a more uniform coverage of the fibre matrix?

The fibre matrix should be as regular as possible, with sufficient smoothness before pigmenting.

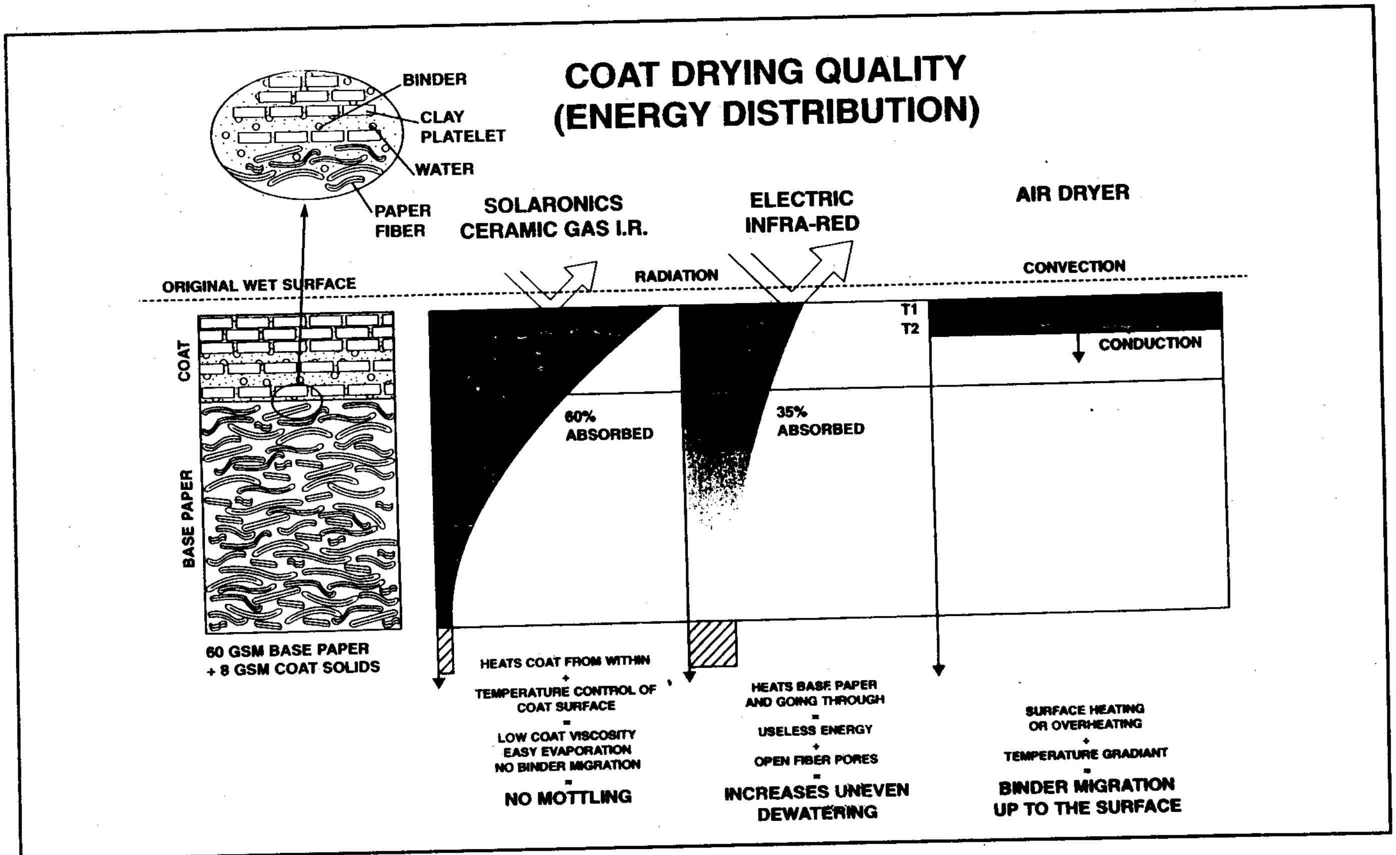


Fig. 4

The application equipment must be capable of distributing the pigment evenly across the whole of the surface.

The pigment formulation (appropriate pigments, binder system, co-binders, etc.) must be adapted to the base paper, the film applicator, the calendering method. . . and the printing requirements (ink gloss, receptivity, ink drying, surface porosity, paper gross, etc.)

Coating colour transfer factors are of prime importance in a film coating application (viscosity, rheology, water retention, pick strength, glossing effect, resistance to blackening, etc.).

Infra-red suppliers are required to deliver a high density, non contact drying system for even drying of the coating which will avoid mottling problems.

The challenge for quality is to form associations between the papermaker, and the coating and drying specialists. Separately each discipline is not fruitful and one weak partner will lead to failure.

What are the different steps in the pigmenting or coat drying process?

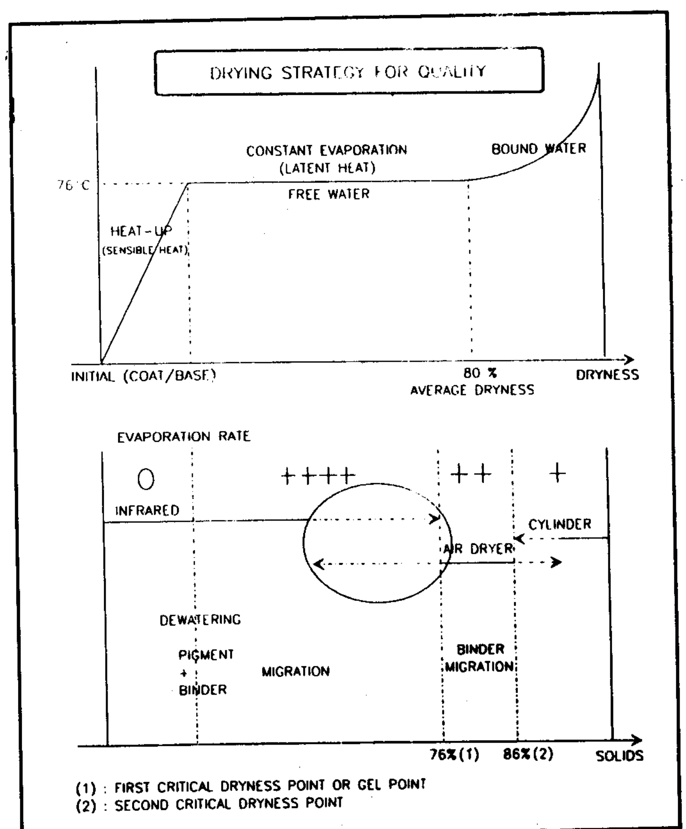


Fig. 5

- Coat heat up to 76°C.:

  De-watering from the coat into base paper starts immediately under the nip of the coat application and continues during the draw up to coat gel point.

- Coat gel point : First critical dryness point (or First Critical Concentration F.C.C.) 76% coat solids.

  At this point de-watering is stopped - there is still, however, the possibility of binder migration.

- Second critical drying point (or Second Critical Concentration S.C.C.) 86% coat solids- No further migration occurs.

Even suppliers having air-dryers in their product range agree that for quality (mottling problems) there is a need to complete the heat-up phase and start evaporation with infra-red in order to stop de-watering. Thanks to the high power density and the ability to dry the coat from within, the infra-red will prevent uneven de-watering.

Quality wise the best drying strategy following a **pigmenting or coat** application is to be close to gel point immediately after infra-red application.

Following the infra-red system, air dryers (eventually) and drying cylinders (to control curl and for web tension) are installed.

Power to each system is set according to the a.m. strategy. There is always a possibility, with a Solaronics system, to either switch-off rows of emitters or to reduce the overall power supplied to the system.

Of course each coating formulation, base paper, applicator system and different speeds must be considered in order to determine the correct drying strategy. Flexibility with the dryers must always be borne in mind in order to be able to adjust the drying strategy. It is advisable to have a total drying capacity higher than the calculated drying capacity required. Thus when a mottling problem occurs, it is quite simple to "play" with the respective drying capacity of infra-red and air dryers.

We have many industrial examples where mottling problems have been solved thanks to Solaronics infra-red systems.

Because of the control of binder migration with Solaronics infra-red, savings in binder consumption are also achieved or less expansive binder is needed.

100% drying with IR is achievable when space is a major problem. Our outstanding reference is at RIVA del GARDA in Italy on two On Machine Coaters (BELOIT and VALMET).

The Strategy is to achieve the gel point (F.C.C.) quickly with high power density.

Between the 2 critical dryness points (F.C.C. and S.C.C.) it must be possible to decrease the evaporation rate, with a lower power density. This can be achieved either with power regulation or sufficient free draws (hood Splitting). After the second critical dryness point (S.C.C.), a high IR power density is once again suitable. The final drying cylinders are usually installed for curl control, web tension and web cool down.

M.D. moisture profile control is easily achieved by fast power adjustment of the infra-red system linked to moisture gauge.

The best effect for C.D. moisture profile control is at an evaporation phase when water is not yet bonded (i.e. below 80% dryness). A few last infra-red rows of C.D. moisture profile emitters following straight heating rows is the cheapest and most effective solution.

KEY POINTS TO CONSIDER WHEN CHOOSING AN IR SYSTEM FROM AN END-USER POINT OF VIEW

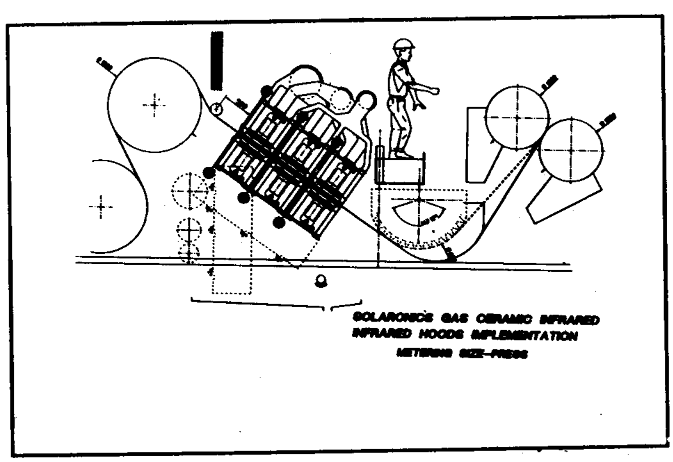


Fig. 6

- High efficiency- use of cheap energy
- Drying quality:
- High radiation/convection ratio,
- Excellent mass transfer,
- Ignition reliability,
- Fire prevention,
- Stand well to air flows (air turns, air dryers...) and to coating and water contamination,
- Control of sheet flutter and prevent sheet breaks
- Ease of threading and readiness to start immediately when coat colour is applied,
- Preventative and scheduled maintenance. Ease of access for maintenance and ease of maintenance.
- Expertise with large width machines

ROHIT COAT APPLICATION REFERENCE

Solaronics has successfully started-up a few weeks ago a system at ROHIT Pulp & Paper in VALSAD GUJARAT on BM4.

It consists in one 2 row hood with 13 emitters per row, operating with LPG utility and installed after the third (top) coating station to produce coated board.

The project management, installation and start up went smoothly and according to ROHIT time schedule.

First technical results are on line with customer expectations and the drying "Quality" is excellent to sustain the final board quality.

SOARONICS system safeties are highly satisfactory.

REFERENCES:

(1) K. Hagen, A Fundamental Assessment of the Effect of Drying on Coating Quality - *Tappi Coating Conference (1985)*

(2) K. Hagen, Binder Migration in Paper and Paperboard Coating Effect of Drying (Chapt. 3 - P39-59) - *Tappi Coating Conference (1986)*

(3) K. Hagen, Using infra-red radiation to dry coating *Tappi Journal* 77 (May 1989)

(4) K. Hagen, Effect of drying Binder migration in paper and paperboard coatings - *Tappi press Atlanta (1993)*

(5) J.C. Walter, The coating processes - *Tappi Press Atlanta (1993)*

(6) P. Heikkila, A study on the drying process of pigment coated web - *Akademi Finland, Report 92-125A (1993).*

(7) J. Perry, Flotation, Infra-red drying boosts efficiency of paper coating stage- Paper coating trends - *Pulp & Paper focus book, Miller Freeman (1991)*

(8) P.J. Aschan, Solving Problems of Print Mottle on Coated Board - *Tappi Coating Conference 1988).*

(9) G.J. Quenard, Gas Ceramic Infra-red System: Increased Speed and Quality - *Actim Praha (1994)*

(10) S.X. Pan, H.T. Davis, L.E. Scriven, Modeling moisture distribution and binder migration in drying paper coatings - *Tappi Journal. 78 : 127 (August 1995)*

(11) A. Lemaitre, C. Foussats, Etude experimental de strategies de couchage - *Atip France (Oct. 1993)*

(12) G.J. Quenard, Non contact Drying after Metering Size Press : Unique benefits with gas infra-red - *Asia Paper Singapore (April 1996)*

(13) G. Engstrom, formation and consolidation of a coating layer and the effect on offset print motlle - *Tappi Journal (April 1994)*

(14) Trefz, Theoretical Aspects and practical Experiences for Film coated offset grades - *Tappi Journal vol. 79 (January 1996)*

(15) J.M. Rennes, Metering Size Press Drying and Web Handling Systems - *Tappi Metered Size Press Forum Nashville (1996)*

(16) G.J. Quenard - Drying strategies with gas infra-red : Quality and Savings - *Appita Auckland (May 1996)*