INFLUENCING PAPER PROPERTIES BY SPRAY APPLICATION OF ADDITIVES

A multi-client project of PTS, BASF SE, Cargill Deutschland GmbH and interested partners from the paper industry in the pilot plant of PTS Heidenau.

The start-up meeting served to adjust the project objectives and work programme to the specific needs of the partners involved. For this purpose, it was decided to subdivide the project into:

- Part 1: Joint elaboration of fundamental knowledge – results are available to all project partners
- Part 2: Development of specific solutions for different applications – results are accessible only to partners involved in Part 2.

This approach made it possible to meet the partners' demands for cost-effective project work and confidential treatment of the customer-specific solutions elaborated. Accordingly, only the general findings from Part 1 will be presented here.

Aims

The project was intended to provide basic information about the effects of spraying on paper properties, depending on additive type and concentration (spray solution) and spraying positions in the process. For this purpose, the following questions had to be answered:

- How does the spray solution penetrate into the fibre mat, depending on the position of spraying in the process?
- Is penetration influenced by additive types and /or concentrations?
- Is it possible to influence or control penetration by technological conditions after spraying?
- Which effects does all this have on paper properties?

The knowledge gained was intended to facilitate and speed up project part 2, i.e. the development of customer-specific, application-oriented solutions.

Trial programme and methodology

Based on pre-tests, the project consortium decided to use the following trial programme (Figure 1).

This included:

- using a starch solution at different concentrations (5 and 10%)
- using a polymer solution (latex)
- spray application of 1,5 g/m² (otro)
- spray application at different positions (Figure 2)
  - o in the wire section
  - o after wet presses and
  - o in the end section.
- influencing the penetration of spray solutions by
  - o varying the dewatering process after spray application in the wire section
  - o varying the drying direction of IR driers after spray application downstream of wet presses
- assessing the penetration of spray solutions by reflected light microscopy and cross-sectional images (project partners Partner BASF SE and Cargill)
- assessing the effects on paper properties
  - o bursting strength
  - o surface strength (Dennison wax test)
  - o water absorption (Cobb60)
- using different stock models provided by project partners from the paper industry

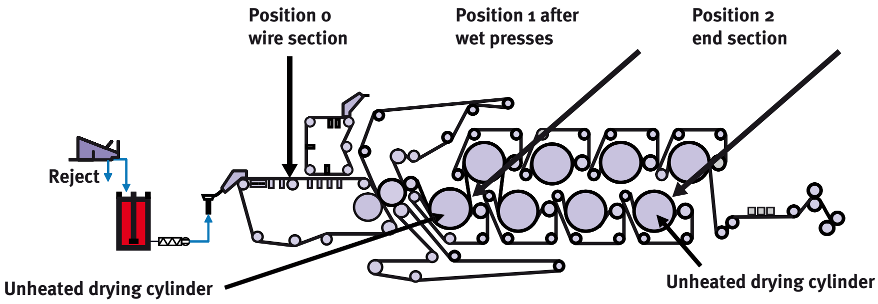
Test stand

Trials were performed on the pilot paper machine at PTS Heidenau. Figure 2 shows the spraying positions in the paper machine.The spray nozzle was a 40cm wide (= web width) two-substance nozzle type 930-33 from the company Düsen-Schlick GmbH. The amount of spray solution applied is determined by machine speed, nozzle capacity and concentration. In our case, the nozzle capacity ranged from 20 to 500 ml/min, making it also suitable for full-scale applications.

Spraying additive		none	Starch 10%	Starch 5%	Polymer dispersion	none	Starch 10%	Starch 5%	Polymer dispersion	none	Starch 10%	Starch 5%	Polymer dispersion	none	Starch 10%	Starch 5%	Polymer dispersion	none	Starch 10%	Starch 5%	Polymer dispersion
Test series		Spraying in wire section								Spraying after wet presses								Spraying in end section			
Spray side		OS	OS	OS	OS	OS	OS	OS	OS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS
Dry content of paper during spraying	%	18	18	18	18	18	18	18	18	38	38	38	38	38	38	38	38	93	93	93	93
Spraying additive	type	none	B	B	D	none	B	B	D	none	B	B	D	none	B	B	D	none	B	B	D
Concentration of spray solution	g/l	0	100	50	100	0	100	50	100	0	100	50	100	0	100	50	100	0	94	50	100
Spray application (oven- dry) grammage difference	g/m²	0	1.5	1.5	1.5	0	1.5	1.5	1.5	0	1.5	1.5	1.5	0	1.5	1.5	1.5	0	1.5	1.5	1.5
Spray application (oven-dry)	% of paper	0	1.9	1.9	1.9	0	1.9	1.9	1.9	0	1.9	1.9	1.9	0	1.9	1.9	1.9	0	1.9	1.9	1.9
Suction box opening after spraying	open/cl.	open	open	open	open	cl.	cl.	cl.	cl.	cl.	cl.	cl.	cl.	cl.	cl.	cl.	cl.	cl.	cl.	cl.	cl.
IR post-drying (directly after spraying)	yes/nein	none	none	none	none	none	none	none	none	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
IR drying	Sprayside verso	none	none	none	none	none	none	none	none	Spray side	Spray side	Spray side	Spray side	verso	verso	verso	verso	Spray side	Spray side	Spray side	Spray side

Figure 1: Trial programme

IR drying was employed after spraying (wet presses and end section) to prevent depositing on the subsequent drying cylinder.



Dry content in wire section:	17% followed by wet pressing, IR drying and cylinder drying
Dry content after wet presses:	35...45% followed by IR drying and cylinder drying
Dry content in end section:	85...90% followed by IR drying and 1 drying cylinder

Figure 2: Possible spraying positions in the pilot paper machine

Summary of results

Figures 4 to 7 show the penetration of spray solutions as a function of spraying position, additive type (starch or pigment dispersion) and technological conditions after spraying.

The penetration of spray solutions into the fibre mat is influenced by their immobilisation points. The immobilisation point (concentration) is the concentration at which a solution can no longer migrate into the fibre mat. It depends on the type of spray solution. Polymer solutions form a film layer when distances

Figure 3: Spaying after wet presses– IR dryer acting on the verso

between them have been sufficiently reduced by water removal, thus rendering migration impossible. By contrast, starch migrates into the fibre mat together with water in the direction of drying; its immobilisation requires higher dry contents.

If starch is applied in the wire section, penetration depends on the subsequent dewatering process (Figures 4 and 5). With gentle dewatering, the starch remains on the surface and is immobilised by the subsequent dry content increase in wet presses and the drying section. The resulting starch film is more or less continuous.

Strong dewatering in the direction of wires causes starch to migrate into the fibre mat.

Figures 6 and 7 illustrate the penetration of starch applied after wet pressing (drying toward spray side) and in the end section. Starch sprayed onto the web after wet pressing cannot penetrate due to the water contained in the fibre mat. Subsequent drying toward the spray side immobilises the starch, causing it to form a film. Spray starch applied in the end section, i.e. onto an almost dry paper web, penetrates the fibre mat by up to one third before being immobilised. There is no starch migration during further drying.

Information gained from the trials:

- Penetration depends on the type and concentration of spray solutions
    - o Polymer dispersions are immobilised to form a film shortly after being applied subsequent treatment steps (dewatering, drying) can influence their penetration only to a very limited extent.
    - o Starch (and other) solutions require minimum dry contents of the fibre mat for immobilisation. Before this, starch migrates together with the water contained in the mat. Starch distributions in z-direction may be controlled via the direction of dewatering/drying.
    - o Starch penetration depends on the concentration of spray solutions. The lower the concentration, the more penetration into the fibre mat.
- The strength properties measured during trials, i.e. bursting and surface strength, tend to correspond with the penetration of spray solutions in z-direction. However, strength development is influenced by further factors like film formation during drying (especially in the case of polymer dispersions).

Conclusions

The project results show that it is possible to systematically influence the strength, surface strength and water absorption of paper by additive spraying. The penetration of spray solutions into the fibre mat and resulting paper properties may be influenced depending on additive type, spray position and the technological conditions after spraying (dewatering and drying).

The findings from this project will help the participating companies decide which technologies they are going to use for quality improvement in the future.

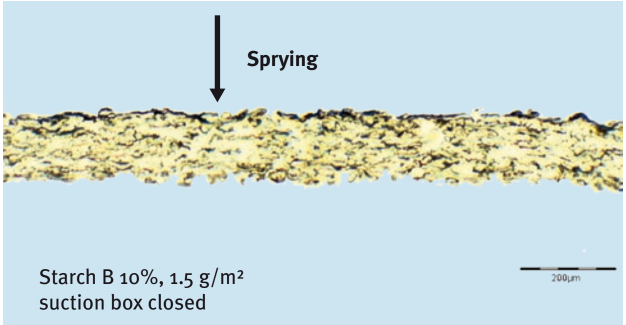


Figure 4: Starch penetration – spray application in the wire section and gentle dewatering

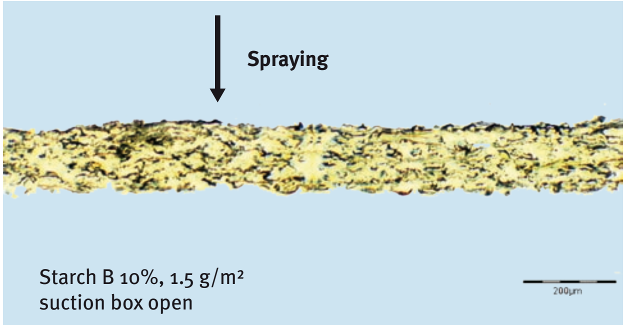


Figure 5: Starch penetration – spray application in the wire section and strong dewatering

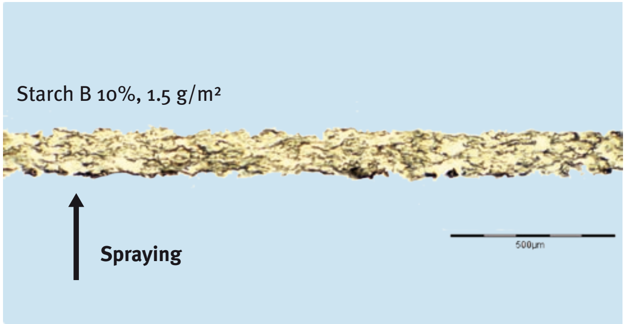


Figure 6.: Starch penetration – spray application after wet presses

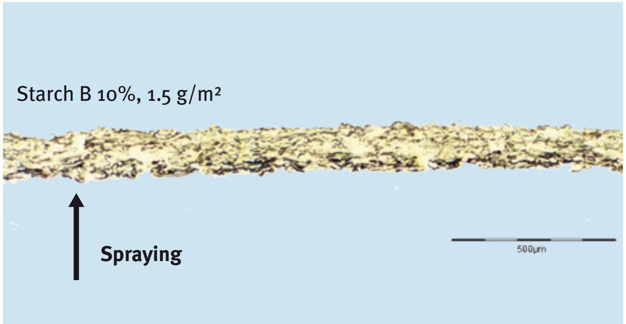


Figure 7: Starch penetration – spray application in the end section

Spray application is another option (beside internal use, surface application by film/metering size presses etc.) which has rarely been used so far for applying/introducing functional additives on or into the fibre mat in papermaking. Spray technology offers the advantage of being a contactless application method, making it suitable also for additives which are incompatible with the pulp suspension and react only when in contact with the fibre mat.

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