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Research area: Process aims
Paper and paperboard production // Surface treatment

Key words:
Coating colour, NIR drying

Title:

Use of new, effective NIR radiation sources for gentle and selective heat transfer in upgrading the surfaces of paper & textiles

Background/Problem

Non-contact drying systems such as convection drying (hot air drying) and radiation drying (infrared drying) have firmly established themselves as the technology for drying paper and textile webs. In addition to their primary function of heating and evaporating the water applied with the coating medium, they must guarantee the high quality of the coating with respect to uniformity, durability and layer adhesion and strength. IR radiators are preferably used as a pre-dryer stage for reducing the migration of finishing agents, coating colours, reactive, direct and dispersion dyes in the paper or textile. Due to the unselective IR radiation excitation in the wavelength range from 2 to 10 µm, the intact liquid film on the surface of the material first may split open, allowing the substrate to absorb more of the radiation energy which in turn may cause partial overheating and damage to the material being treated.

Newly developed NIR boosters have recently been introduced in the sector of liquid and powder paint drying/cross linking to bring about a gentle heat transfer at a greater drying speed. The positive results achieved there appear to promise new approaches to speeding up drying operations with a minimised thermal load in the sector of paper and textile upgrading as well.

The wavelength range of the NIR radiators is a very narrow band and is located at wavelengths from 0.8 to 1.5 µm in the near infrared range (NIR). Thus, NIR radiation provides the shortest wavelength and greatest energy. The radiation energy in the NIR wavelength range is absorbed by all molecules containing –OH, NH- and CH- groups.

Furthermore, the energy density is 1,000 times greater than IR radiation and is thus a considerable advantage. The processing speed can be increased drastically because NIR radiators can input energy with very high efficiency while at the same time controlling the temperature very accurately. Optimisations have already been put into practice in applications like high-speed inkjet, dispersion varnishes in offset and powder coatings. The speeds of the production processes could also be increased by a factor of 1.5 to 3 while at the same time the thermal load of the substrate could be reduced from 80°C to 60°C, for example. The use of NIR technology to dry dispersion varnishes in offset printing also produced an increase in gloss by 20%.

Research objective/Research results

The objective of this research project was to lay down a foundation for the application of narrow-band photon energy input in the NIR wavelength range in fixing, coating and cross-linking processes during textile and paper surface upgrading.

For drying of textiles it has been shown that NIR-radiators allow for a fast removal of water from the substrate resulting in high evaporation rates. The substrates also absorb NIR-radiation which may lead to a fast temperature rise and finally to a deterioration of the substrate after the water has been removed from the coating. Water based polymer dispersions as used in this investigation for textile coating can also be dried within short times. If drying processes were too fast it was not possible to remove the evaporating water in time which resulted in bubbles and blisters within the coating layer. Decreasing the power input reduced this problem, however also lead to lower drying rates. NIR-radiation also allows for a fast hardening of cross-linking components. A very precise process control is obligatory to avoid damages in the substrate or in the coating due to the fast warming. Pigment coating always showed a distinct influence on the rates of warming and evaporation.

Conventional components of paper coating colours exhibit only little absorbance of the NIR-radiation. Lab investigations with different paper bases (wood free, mechanical and recycled fibre based) and typical coating formulations still proved that NIR radiators are effective drying tools. Highly absorbing colour components like carbon black or specialized pigments in the formulations can distinctly accelerate drying speed, but may influence important quality criteria like paper brightness. Critical surface temperatures above 150°C as measured in the lab have not been measured under pilot conditions.

One single row of NIR radiators (approx. 76 kW) was capable to replace two to three rows of Gas- IR dryers with a total power of about 100 kW repeatable in pilot trials with different coating colours. Smaller space requirements and higher efficiency are obvious advantages in the drying process of paper coatings. Occasional losses in surface smoothness and brightness, which have been encountered in a few pilot runs only, need to be investigated case-by-case in more detail. Small amounts of highly absorbing specialty pigments allowed for a reduction of more than 30% of the IR power input without changing final paper moisture or quality parameters of the paper.

Application/Economic benefits

The new drying technology and the special absorbing coating colour components allow for an improvement of paper manufacturing as well as printing economics and economics of textile coating. The medium-sized enterprises of the supplying industry of paper manufacturers with a high flexibility in manufacturing new products in smaller scales can benefit from the development of drying components for high-efficiency drying as well as from the development of new and effective coating colour components with good absorption of the wave-length used for drying. Thus, effective contributions for overall energy savings are expected.

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Remarks

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