Drying of Barrier Coatings

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Drying of Barrier Coatings

- Introduction
- Difficulties in Drying Barriers
- Physics of Drying
- Blistering Free Drying of Barriers
- Practical Experiences

Introduction

- Paper mills try to supply paper with
  - added value for
  - improved gross margin

- Barrier papers and boards is a potential market

Difficulties in Drying Barrier Coatings

- Drying away the water forms the barrier.

- Premature formation of barrier layer leads to micro blistering.

Physics of drying

- Drying is a two step process
  - **Heating** the matter to be dried
  - **Evaporating** the water from the matter to be dried

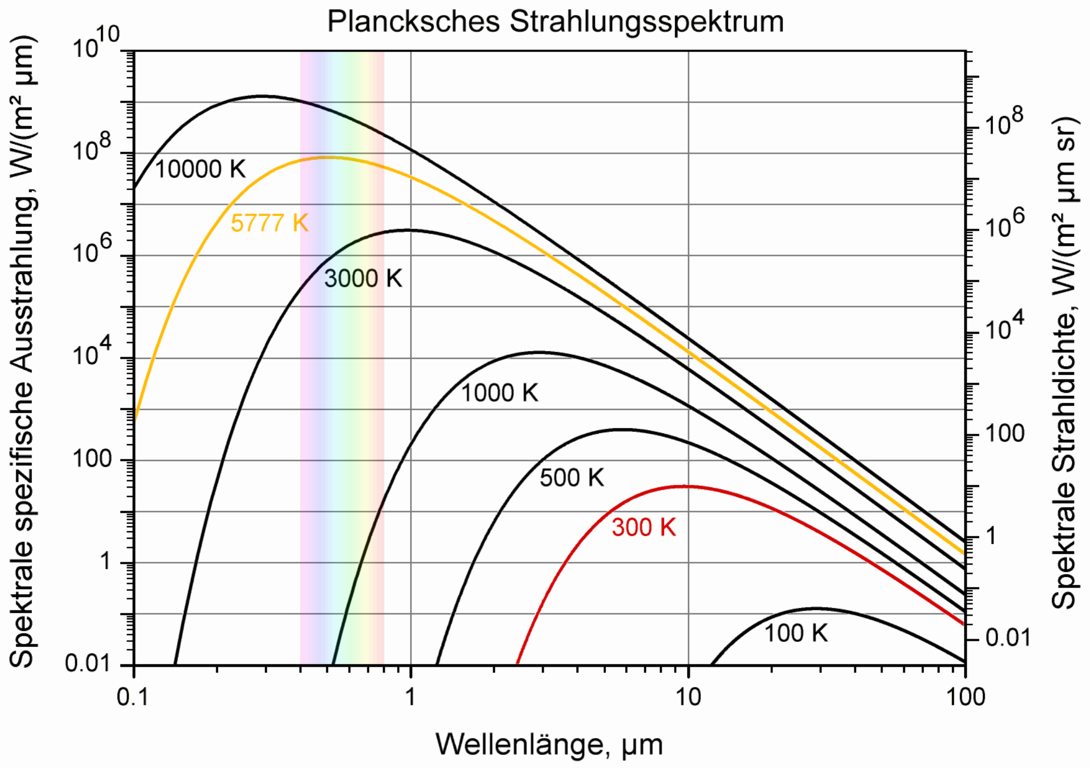
Heating Principles

- Heating by means of
  - Conduction – Cylinder
  - Radiation – Infrared (or Microwave)
  - Convection – hot air (or hot water or oil)

Heating by hot air

- Heats just the **surface**.
- **Slow** to avoid premature film formation on surface.

Heating by Radiation



Gas fired MIR:
peak radiation between 2.5 and 3.5 µm, which corresponds to 1.160 to 830 K

Standard electrical NIR:
peak radiation at 1.18 µm, corresponding to 2.450 K

Enhanced electrical NIR:
peak radiation at 1.45 µm, corresponding to 2.000 K.

Temperatures following Stefan-Boltzmann and Wien's law of displacement

Absorption of Infrared Radiation

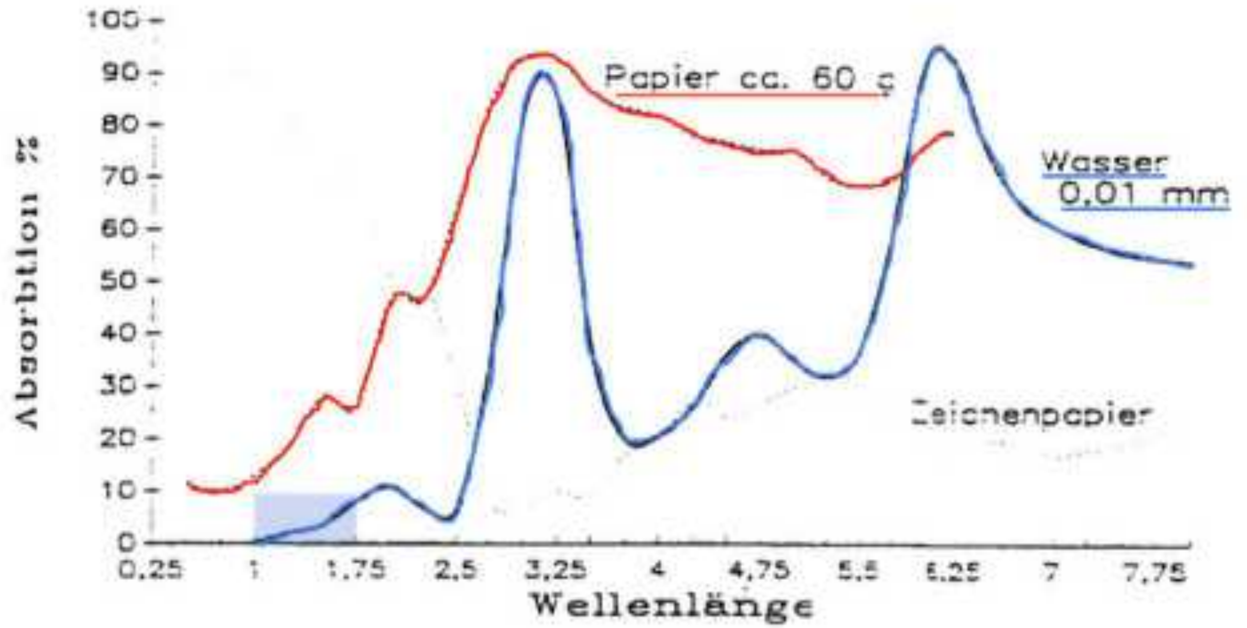
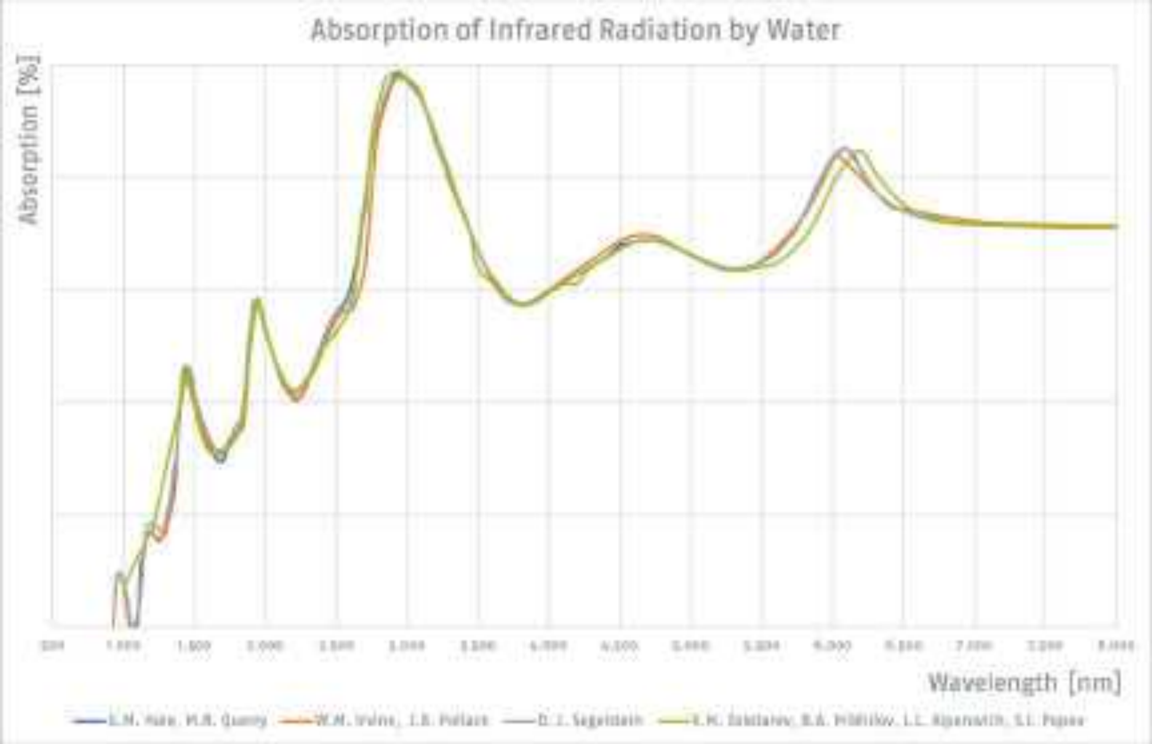


Abb. 7: IR-Reflexion und Absorption von Papier und Wasser

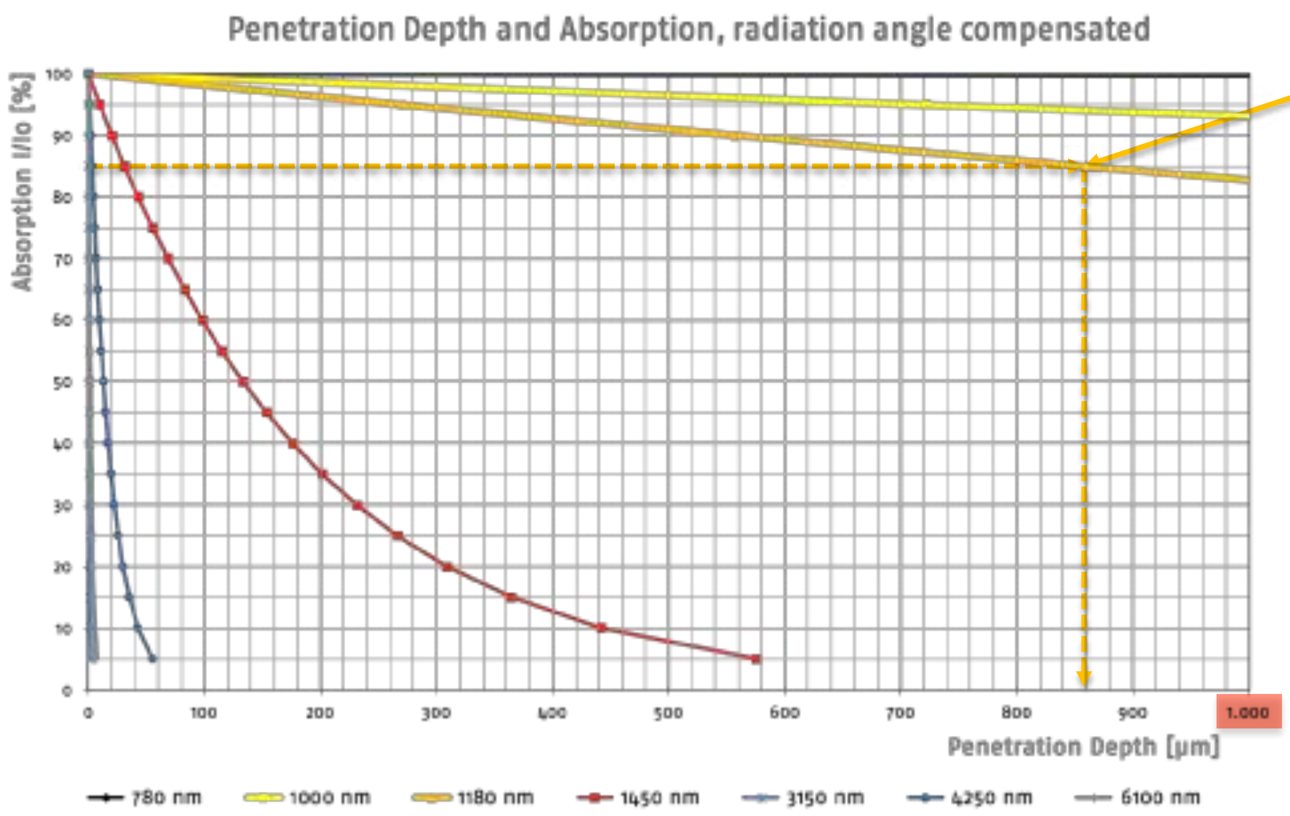
Source: Influence of emitter temperature of infrared emitters upon drying performance
Helmut Graab, Wochenblatt für Papierfabrikation 19/1991

Absorption of Infrared Radiation



Virtually no absorption of infrared radiation by hydrogen bonds at wavelength below 1.3 µm

Penetration following Lambert-Beer Law

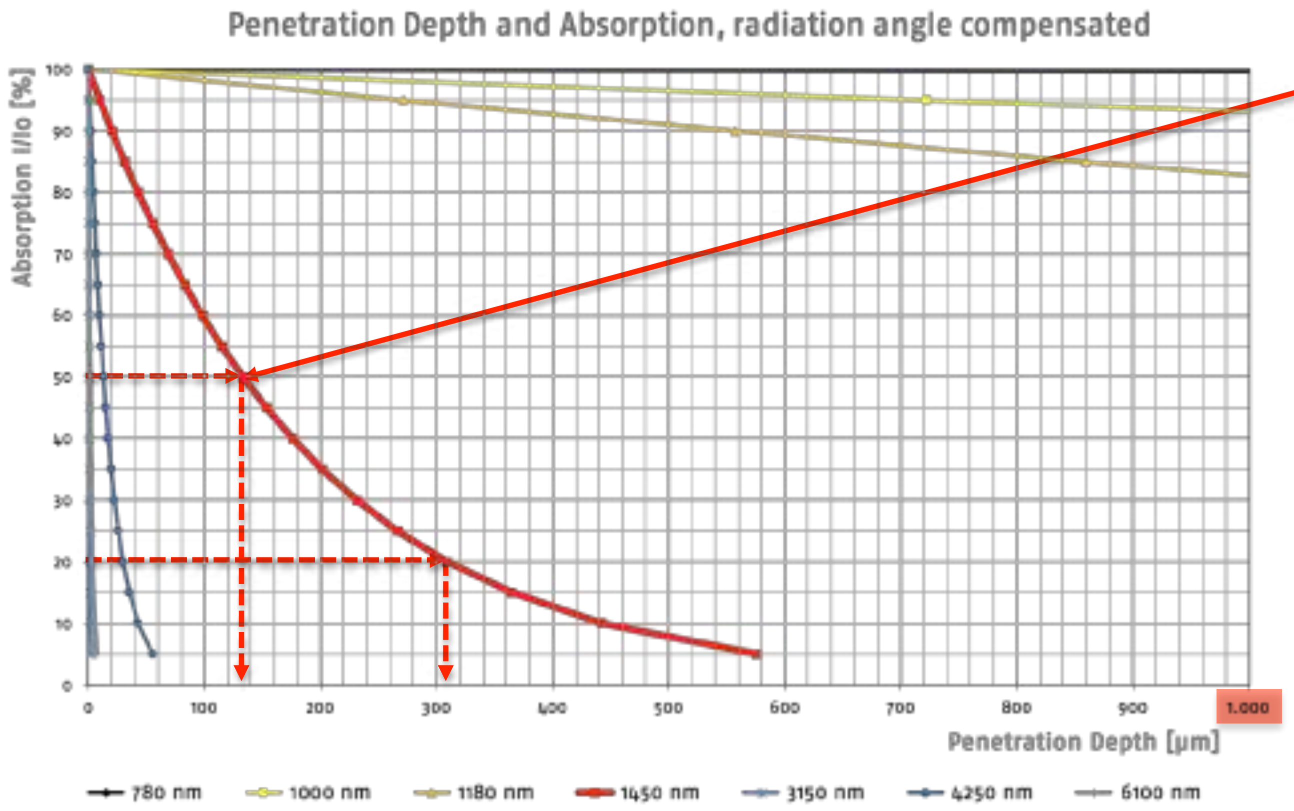


Radiation of electrically powered NIR emitters
(peak wavelength 1,18 µm) penetrates very deep with little absorption.

Penetration underneath the coating, heating the substrate – but not sufficiently efficient.

In 860 µm depth, just 15% of the radiation is absorbed

Penetration following Lambert-Beer Law

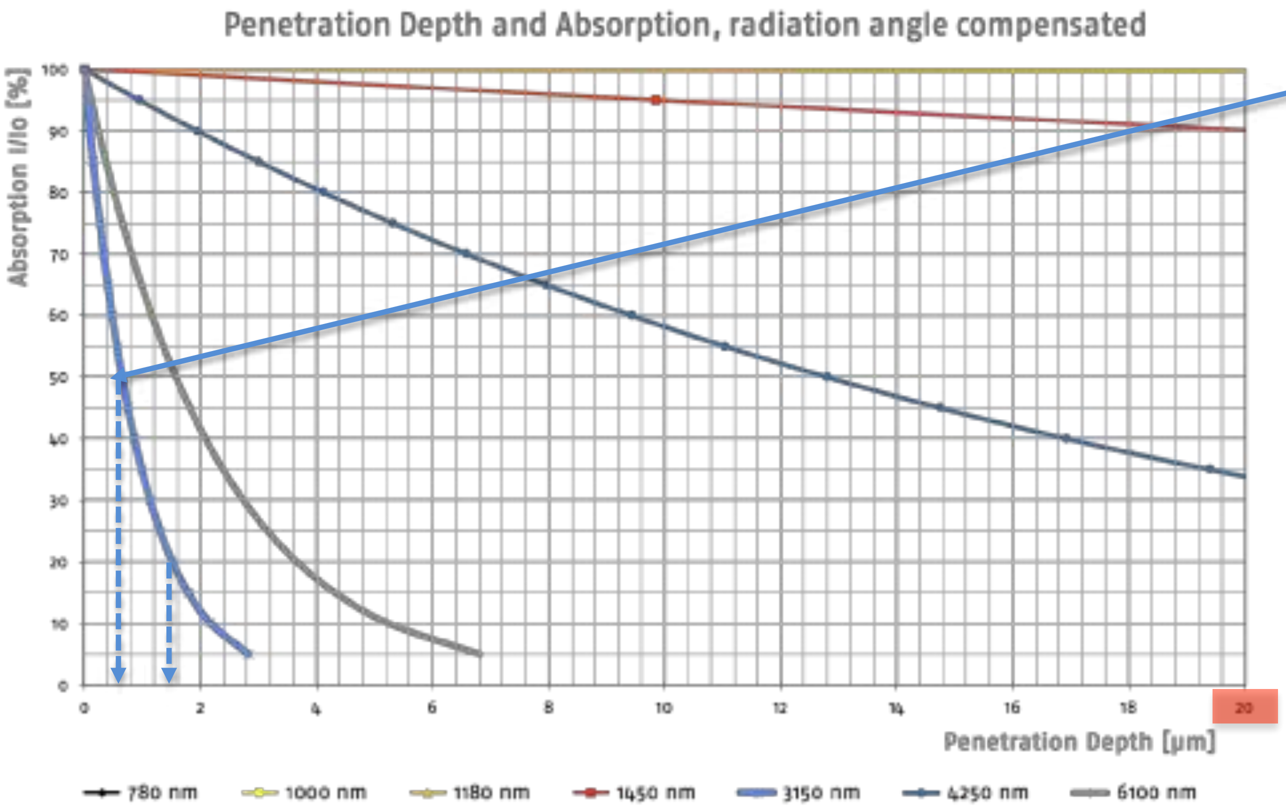


Enhanced electrically powered NIR emitters (peak wavelength 1,45 µm) penetrates deep into the substrate with strong absorption.

50% are absorbed within 135 µm, 80% are absorbed in 310 µm depth.

Penetration deep underneath the coating, with strong warming of the substrate.

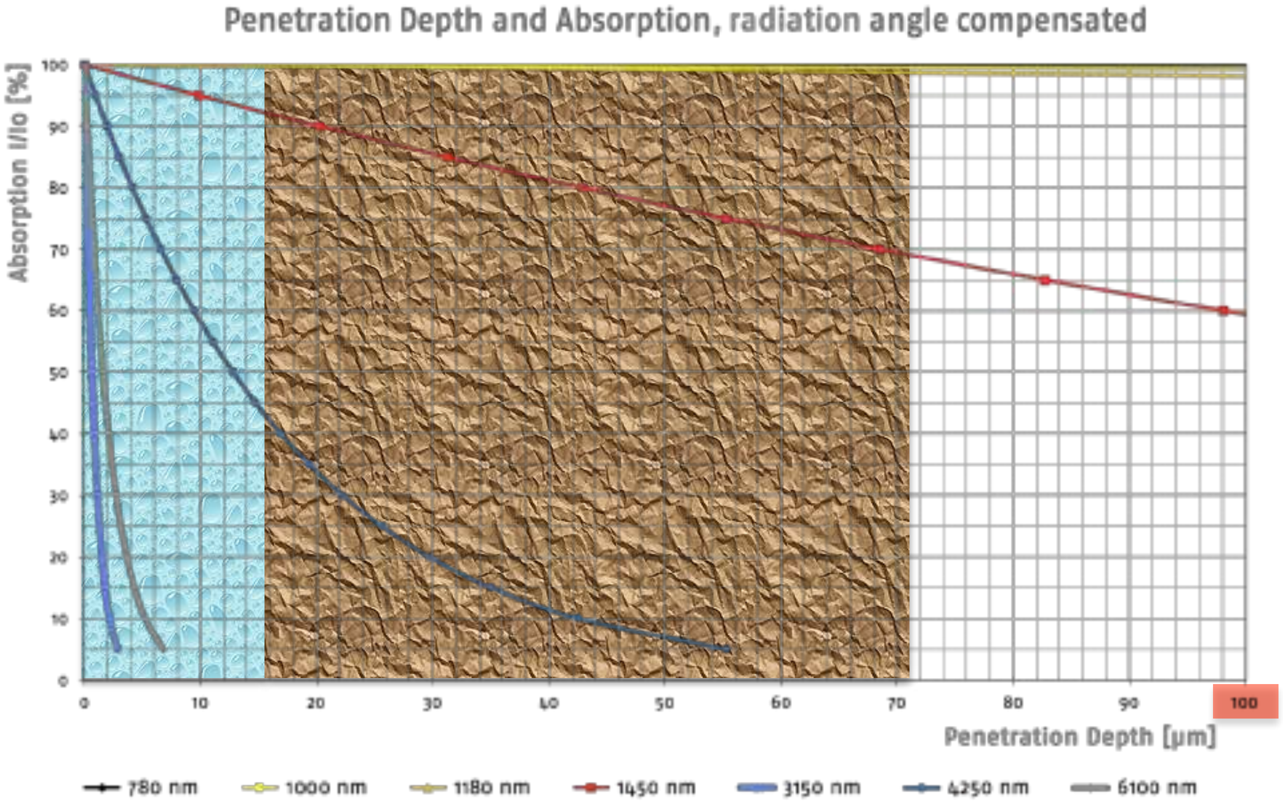
Penetration following Lambert-Beer Law



Gas-generated MIR infrared radiation is absorbed within few microns.

At peak wavelength, 3.150 nm, 50% is absorbed within 0.5 µm 80% within 1.5 µm depth

Premature Film Formation



MIR radiation (peak wavelength at full load = 3,0 µm) is mainly absorbed in the coating.

50% are absorbed within 1.3 µm, 80% within 3.0 µm depth.

Virtually no penetration underneath the coating.

Premature film formation on surface.

Blistering Free Drying of Barriers

- Heat predominantly the substrate
  - selecting as short wavelength as possible

- Prevent excessive losses in the spectrum of 1.18 µm and below:
  - have maximum peak wavelength between 1.4 and 1.8 µm

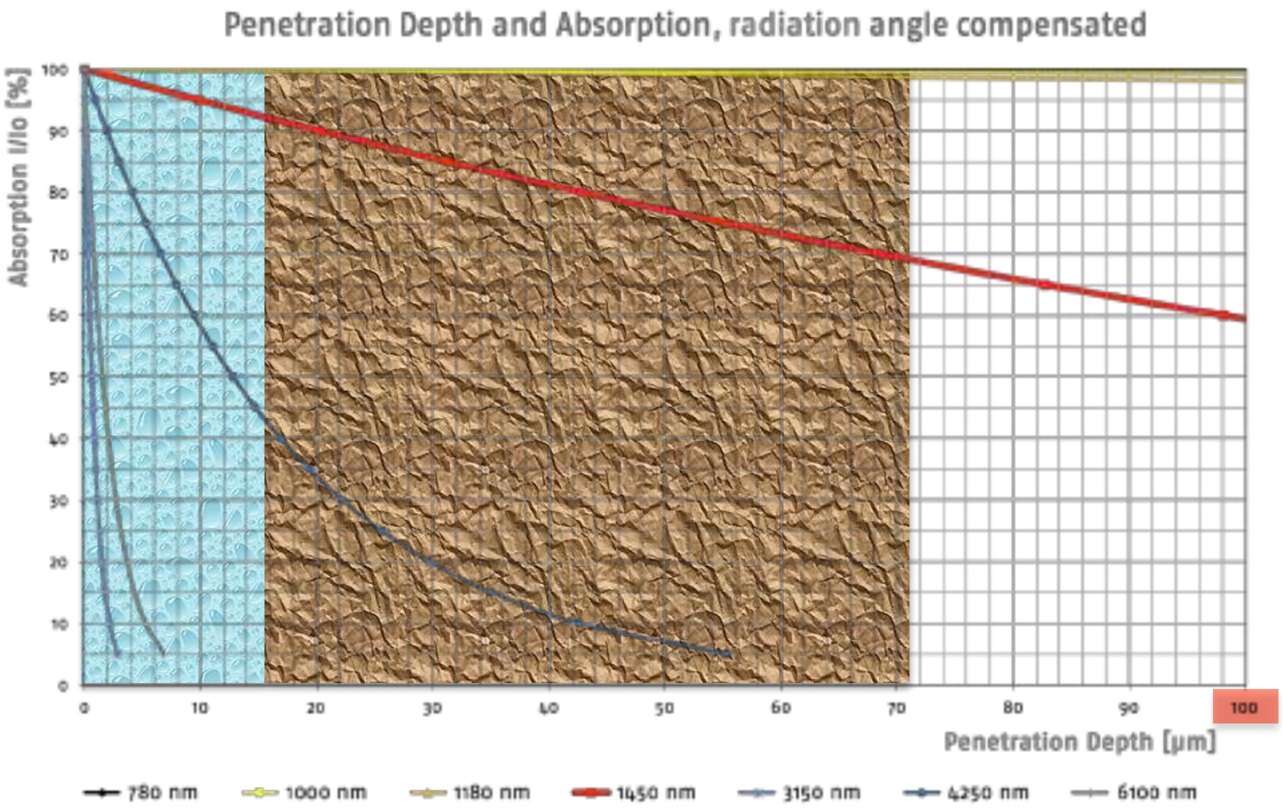
- Avoid saturation of boundary layer through turbulent impingement

Blistering Free Drying of Barriers

- XenTec dryer with peak wavelength of 1.45 µm at full load.
- Deep penetration to heat the substrate.
- Impingement air
  - before,
  - during and
  - after heat input

  for immediate evaporation

Absorption following Lambert–Beer's Law



- Deep penetration into the substrate with strong absorption.

Barrier film formation starts at initial sedimentary layer on substrate.

Surface film is formed only after all water is evaporated.

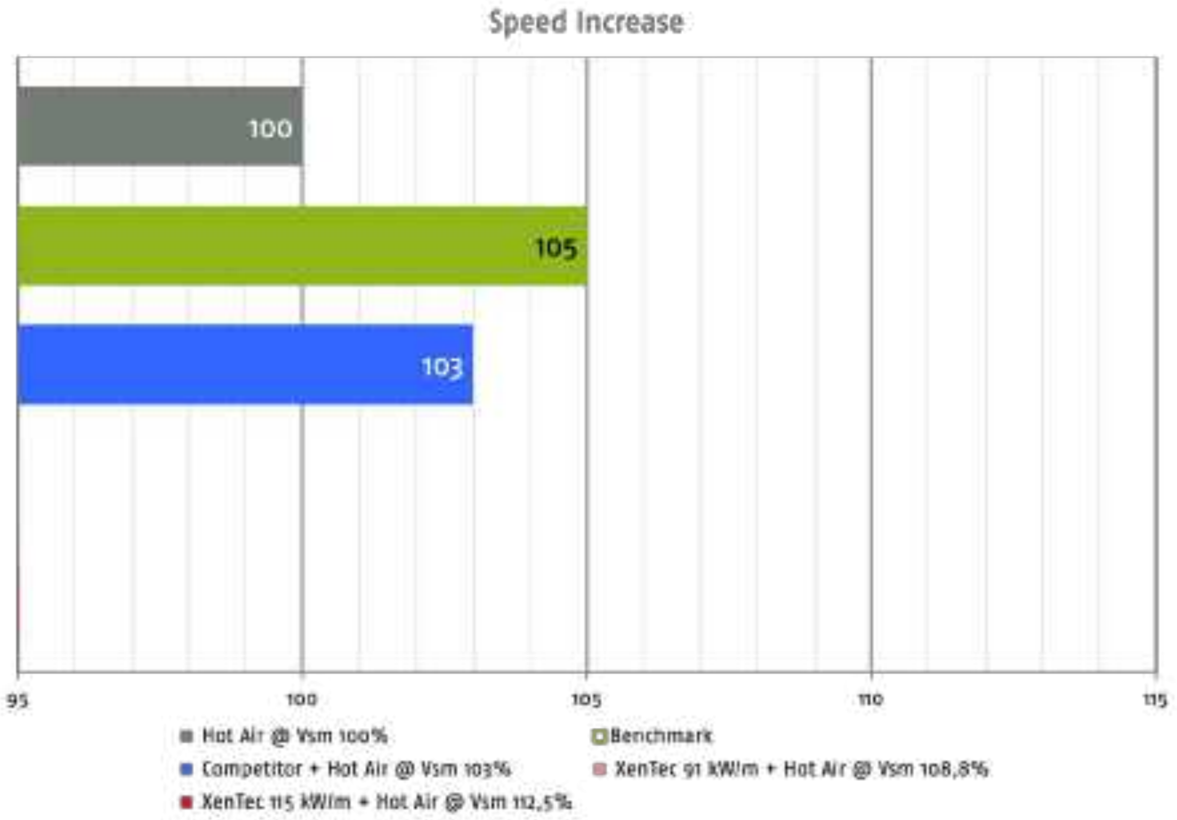
Practical Experiences

- PVA barrier
  - Coat weight 1.2 gsm
  - 8% solids
  - 15 gsm wet weight
- Coater has multiple coating heads on both paper sides.
- Speed limitation on the PVA coating drying.
- Hot air hoods are used, limiting the speed.

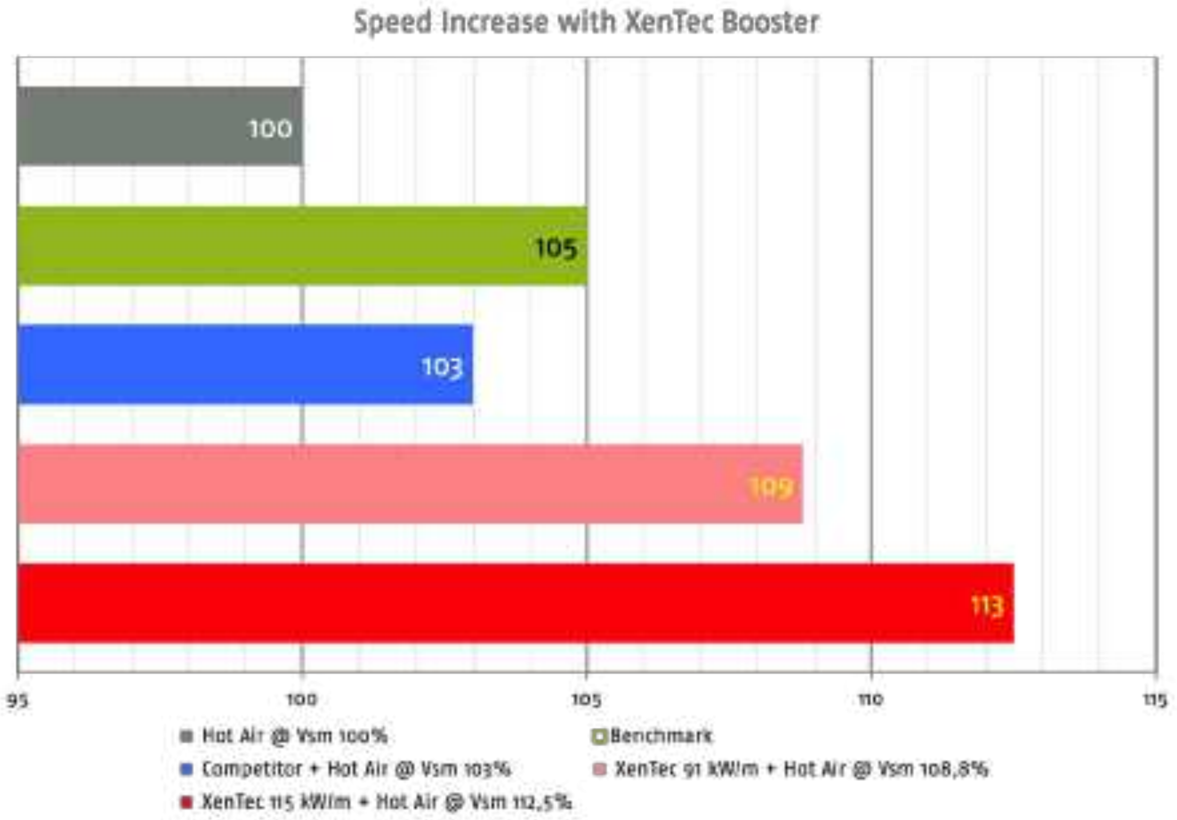
Practical Experiences

- 1 XenTec booster before hot air hoods.
- 1 reflector to minimise energy losses.
- Required Space md: 50 cm
- Installed Capacity: 160 kW/m width

Practical Experiences

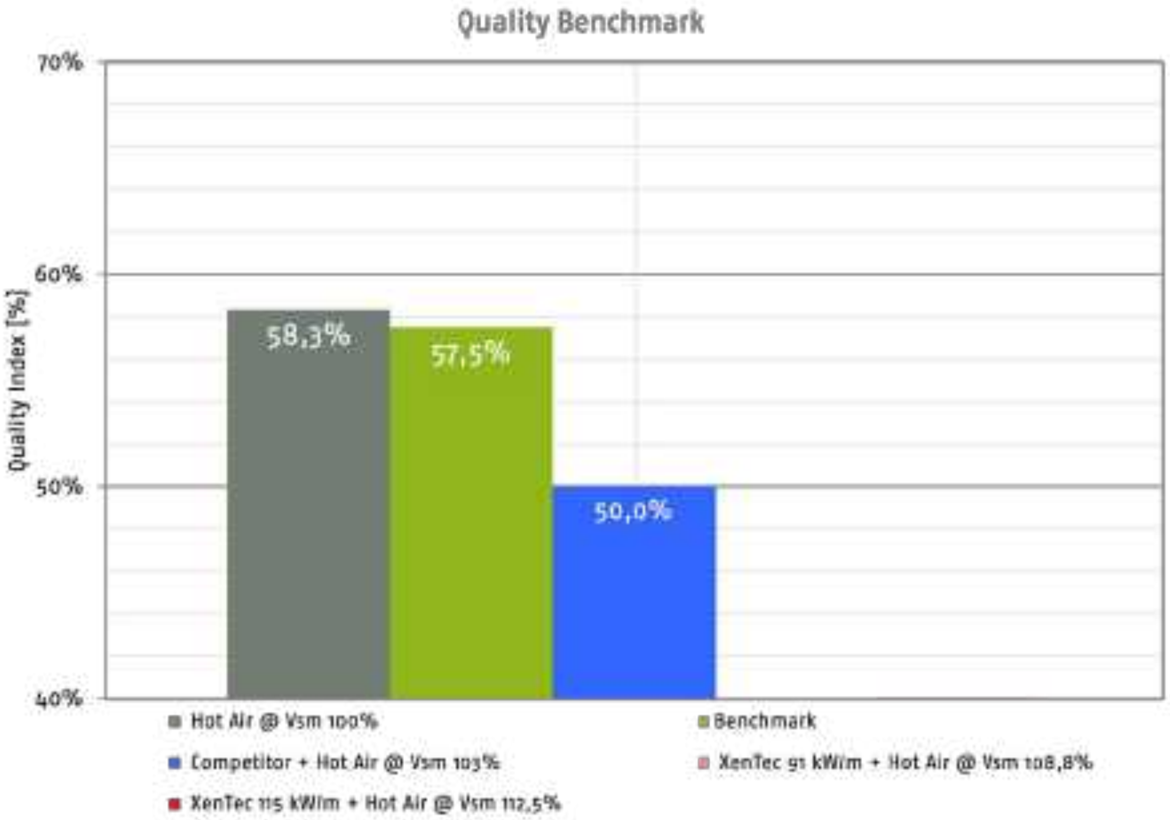


Practical Experiences

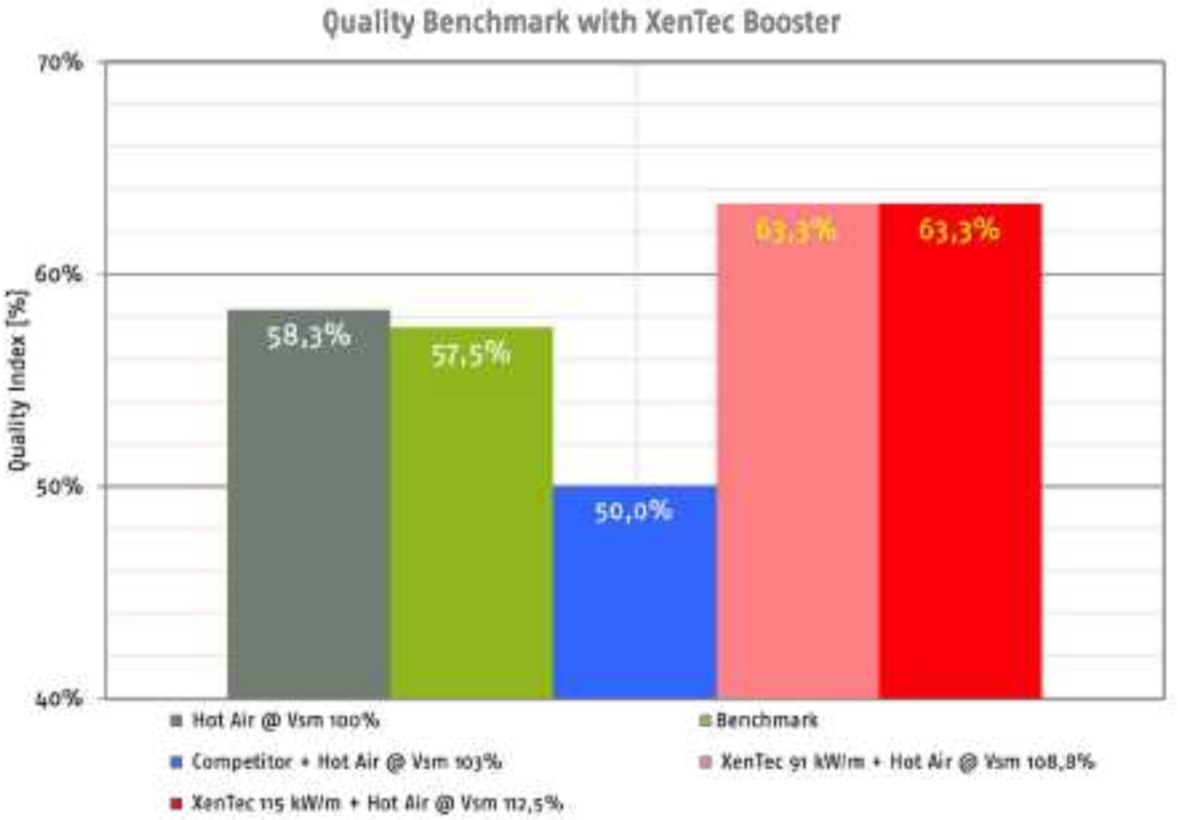


XenTec Booster allows significant increase of production speed, well beyond the limits of conventional electric infrared emitters.

Practical Experiences

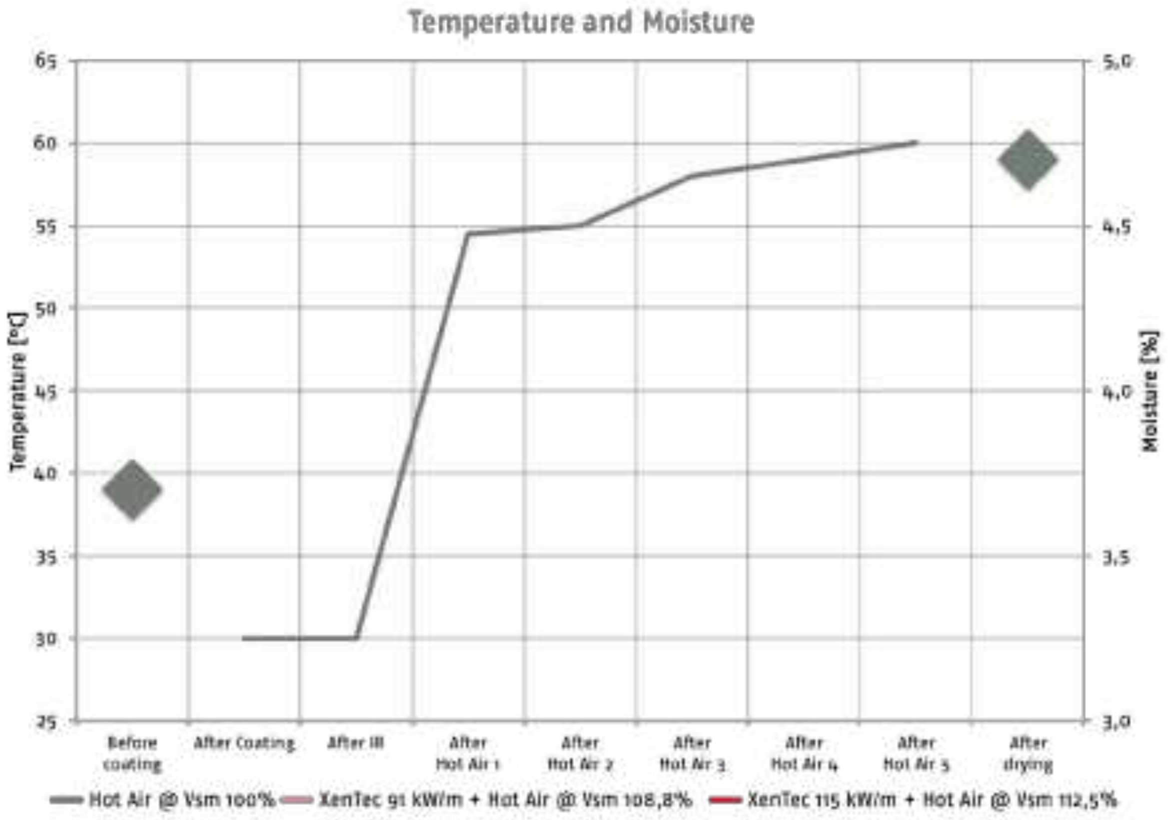


Practical Experiences

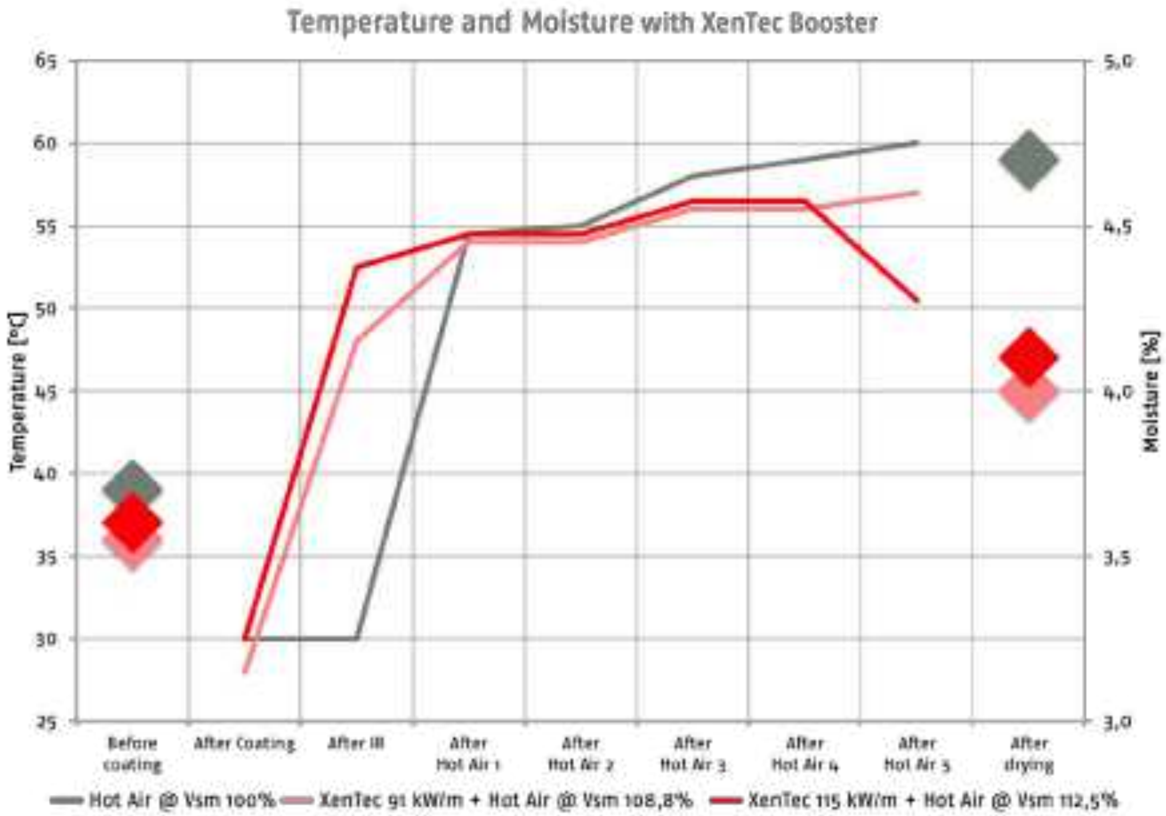


Despite increased speed the quality, namely the barrier functionality, is improved.

Practical Experiences



Practical Experiences

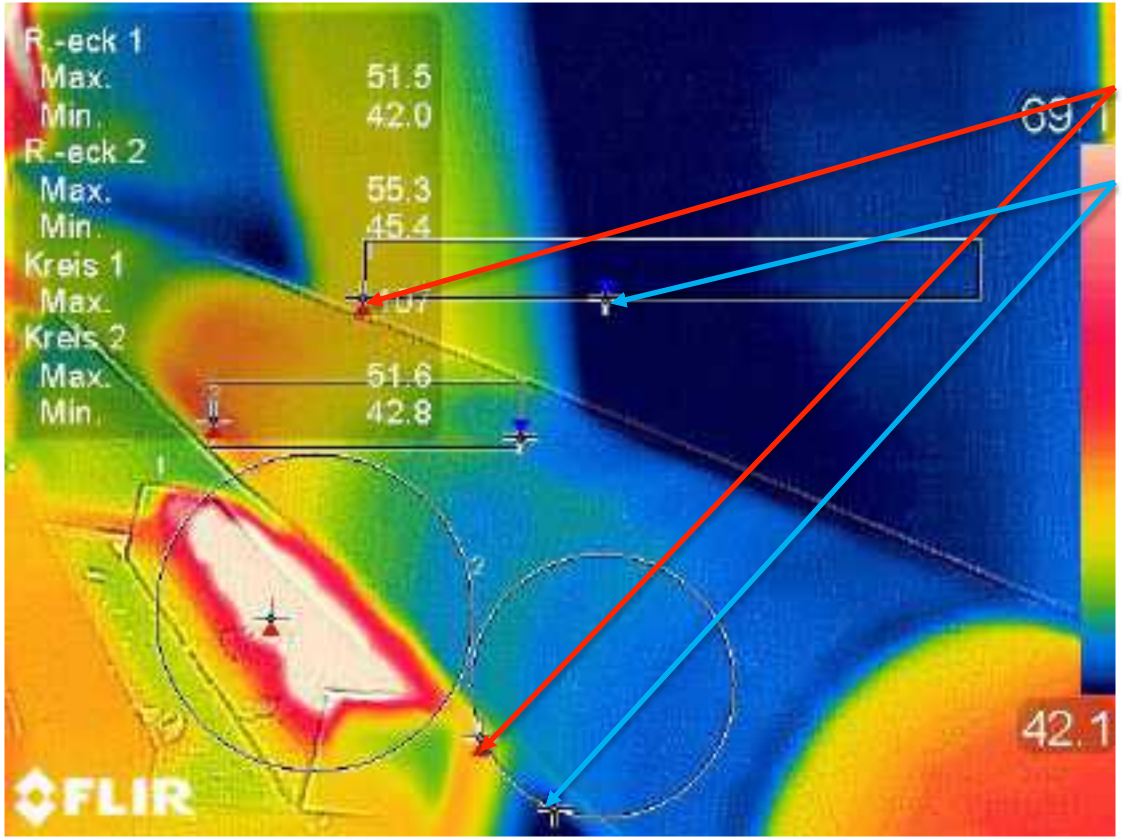


Quality improvement through lower sheet temperature.

Improved evaporation rate delivers stronger cooling of the coating.

No risk of premature film formation on the surface of the coating.

Practical Experiences

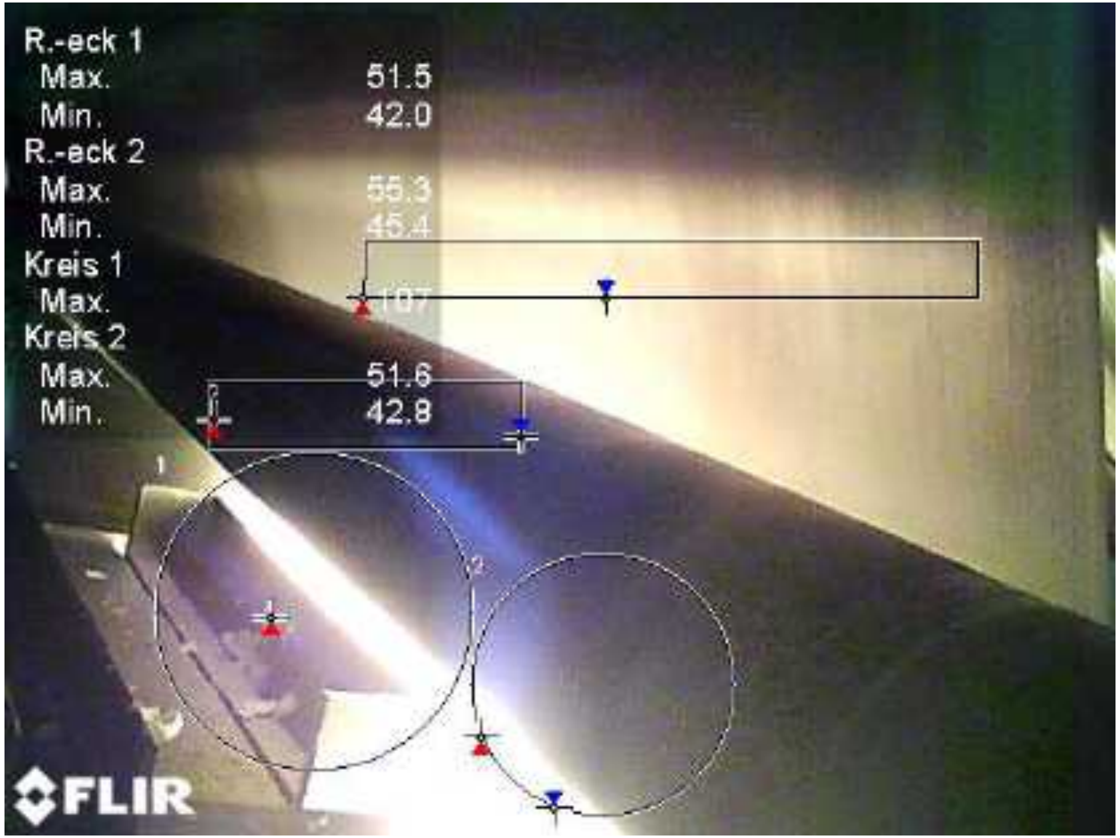


The sheet reaches max. temperature of 51.6°C under the emitter, with standard temperature 42.8°C.

This is a result of successful evaporation already during heating.

Evaporation must happen faster than heating, keeping coating and substrate cool

Practical Experiences



Summary

- Drying of Barrier Coatings without affecting negatively the barrier properties is possible:
  - Selecting the right wavelength for heating the substrate.
  - Starting film formation at initial sedimentation layer.
  - Selecting the right evaporation regime to prevent premature barrier formation on the surface.

Thank you

- Questions?