Third International Conference **CONSOLFOOD**2020

Advances in Solar Thermal Food Processing

22-23-24 January 2020

INSTITUTE OF ENGINEERING; UNIVERSITY OF ALGARVE; CAMPUS DA PENHA; FARO-PORTUGAL

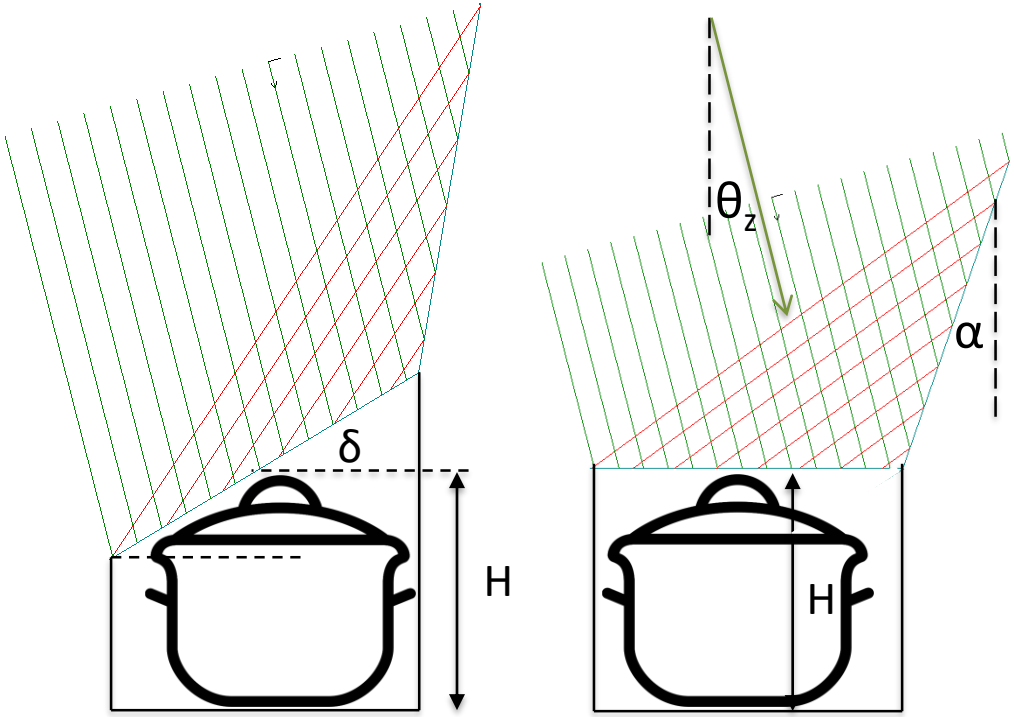
Box Cooker Glazing: Sloped or Horizontal? A Study of the Optical Efficiency

Daniel Feuermann

Ben-Gurion University of the Negev, Blaustein Institute for Desert Research, Israel

Typical box cooker

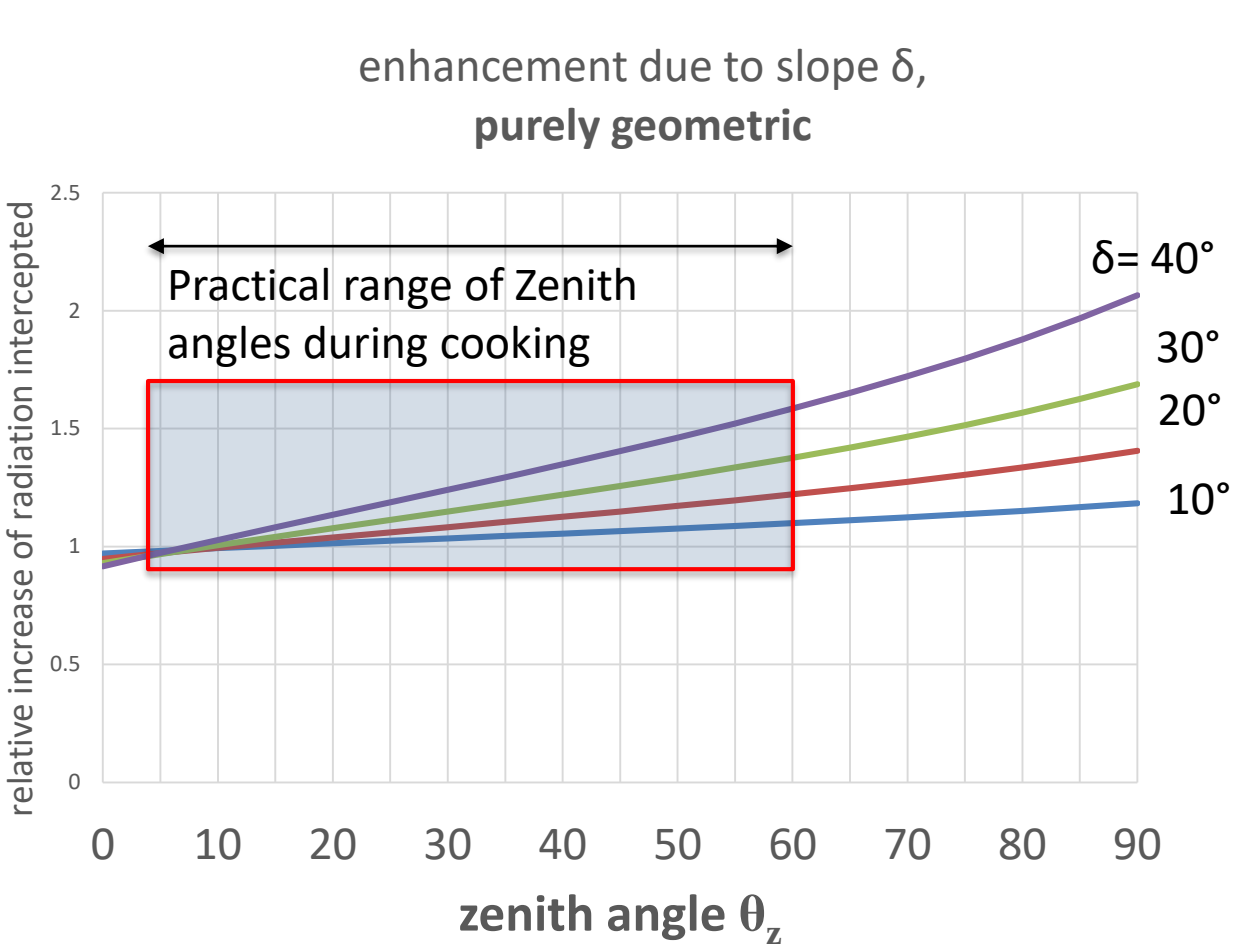
© SunTaste by SunOk, Portugal

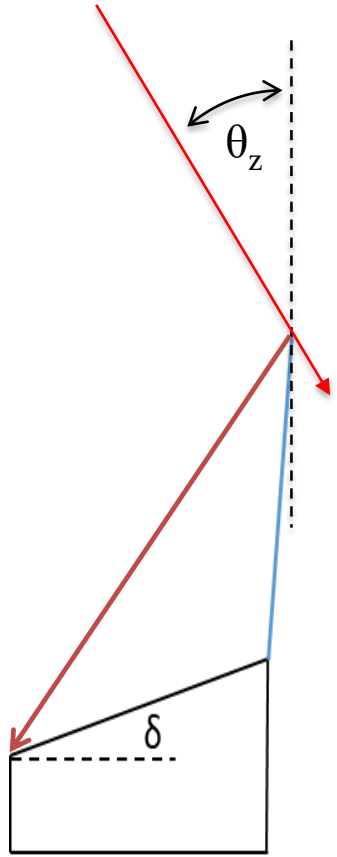


Example:
Slope angle δ = 30°
Zenith angle θ_z=15°

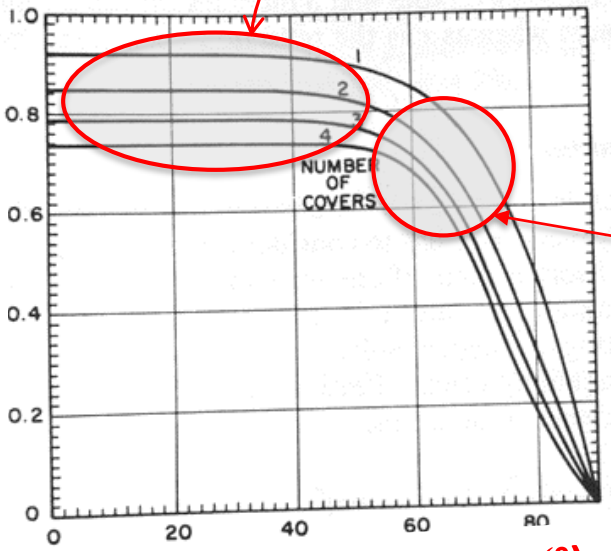
Basis for comparison and assumptions:

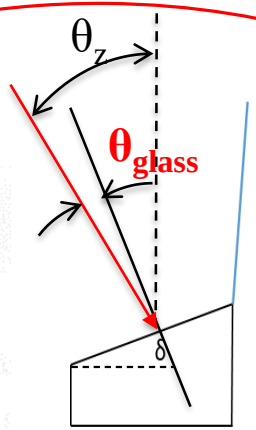
- **Identical footprint, variable slope angle δ**
- **Cooker is aligned azimuthally (i.e., facing the sun at all times)**
- **Mirror is size of glazing, its reflectivity ρ = 0.9**
- **Two 4 mm clear glass panes (abs. coeff. K=9.25m^{-1})**
- **Mirror is always tilted (α) to maximize radiation input ($\alpha=30°-\delta/3-2/3\ \theta_z$)**
- **Negligible increase in heat loss due to change in glazing area (see later)**

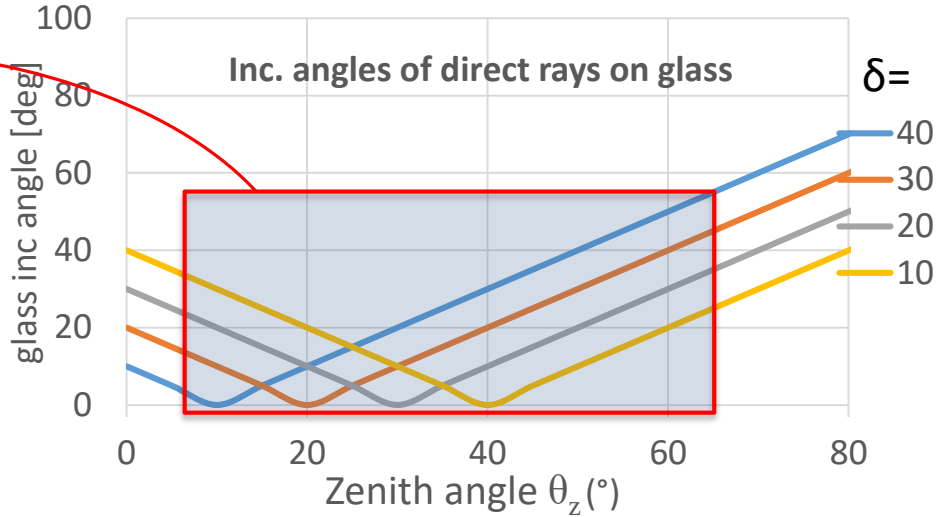

enhancement due to slope δ,
purely geometric
relative increase of radiation intercepted
2.5
2
1.5
1
0.5
0
Practical range of Zenith angles during cooking
δ= 40°
30°
20°
10°
0
10
20
30
40
50
60
70
80
90
zenith angle θz

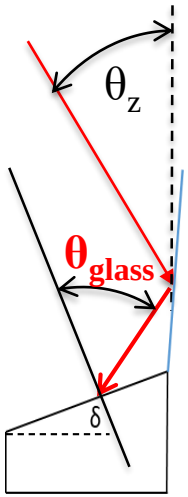

θz
δ

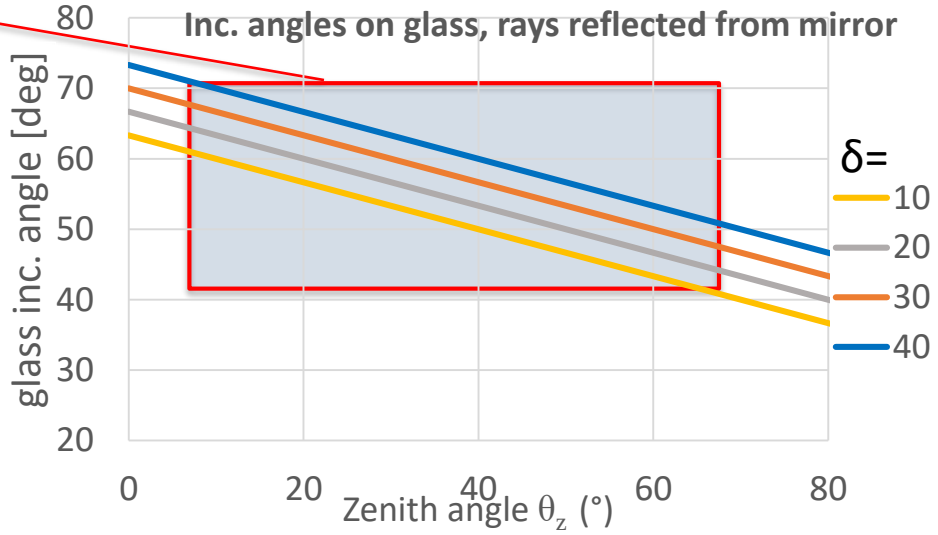
Effect of Fresnel reflections





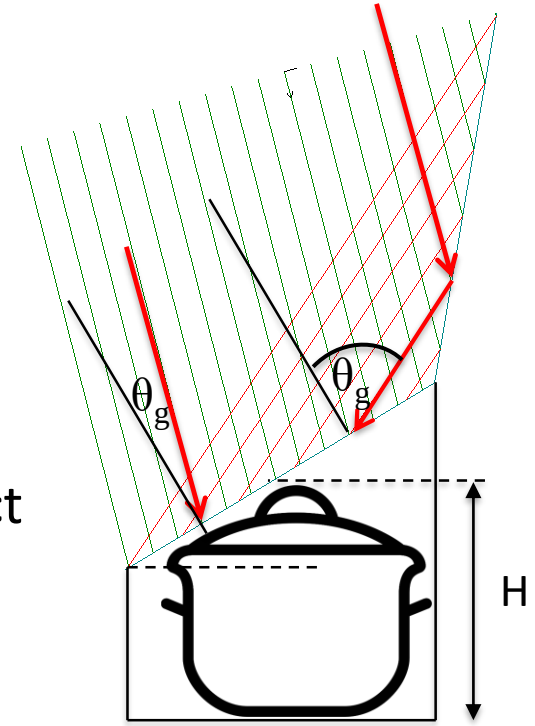


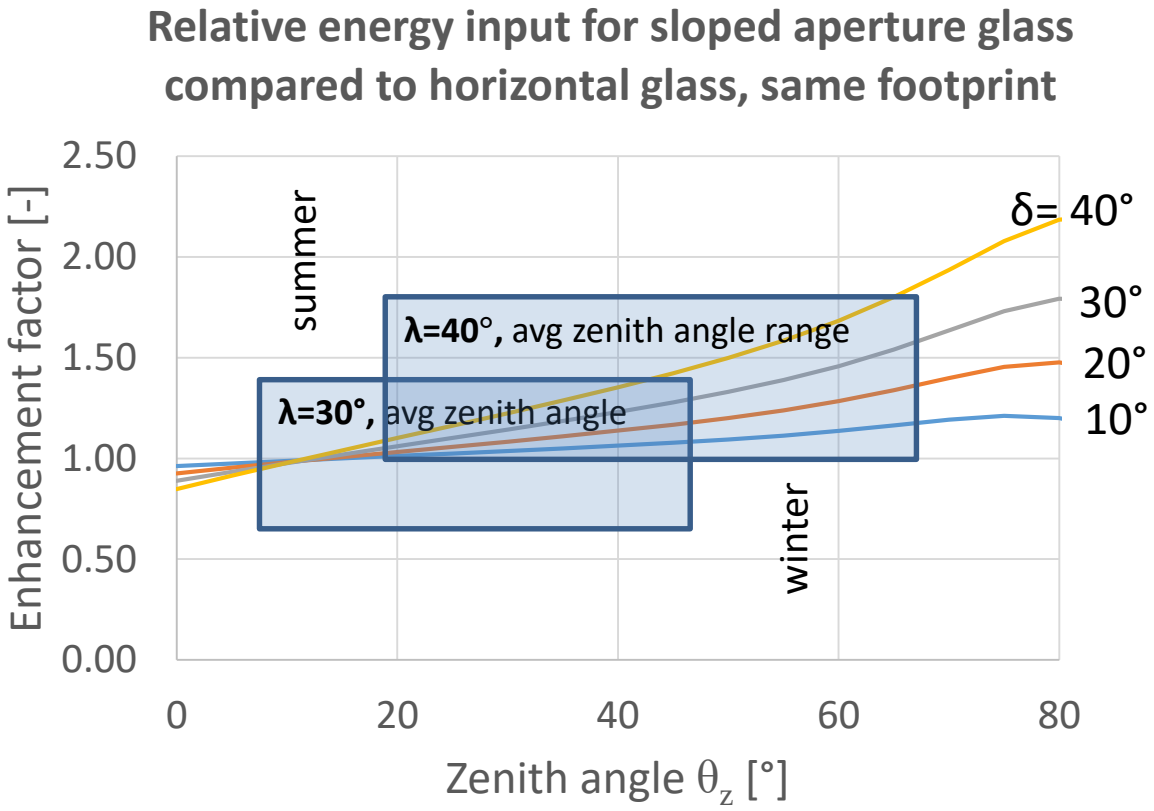




Points to observe:

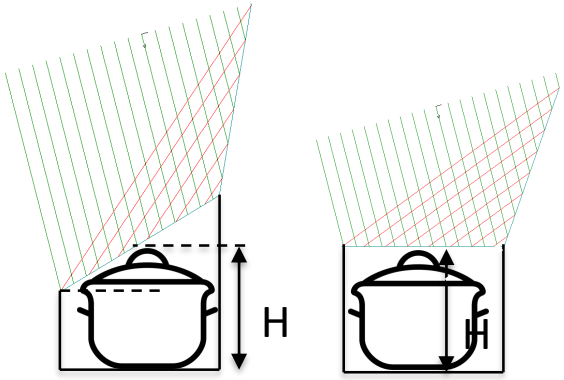
- The glazing and mirror areas increase by 1/cos(δ).
- Sloped glass causes higher incidence angles θ_g of ***reflected*** rays,
- causing larger Fresnel reflections, and higher absorption in the glass. But it is better for direct radiation (smaller angle on the glass).
- The total intercepted beam radiation increases with δ (and to good approximation also the diffuse radiation, but not by the same factor).
- The possible advantage varies with the zenith angle, higher Zenith angle demands higher δ.





- Includes mirror reflectivity of 90%
- 4mm glass,
- Extinction coeff. $K=9.25m^{-1}$
- λ: Latitude

Comments



- Additional heat loss:

Letting the ***average box height*** constant, only the larger Glazing area adds to the heat loss: for typical values of side insulation and glazing loss coefficients, the additional loss when δ=30° is ~6 to 10%, while at medium zenith angles, the energy input is 25-35% higher in summer, and up to 50% higher in winter.

- Diffuse radiation

Assuming it is ~20% of radiation (clear days), its contribution is not increased by the mirror but it does increase with glazing area. Due to the slope, the view factor to the sky is reduced a bit. So all in all it will hardly affect the energy balance.

- Conclusion:

Sloped glass is better for higher zenith angles, i.e., for early morning/late afternoon cooking and, of course, for ***higher latitudes***.