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## - To cite this version:

Solmaz Boroomandi Barati, Jean-Charles Pinoli, Stéphane Valette, Yann Gavet. Mathematical model of dropwise condensation on textured surfaces. Khashayar SALEH. 9e Colloque Science et Technologie des Poudres - STP 2018, Jul 2018, Compiègne, France., Actes_STP2018, pp.99. hal-01851661

HAL Id: hal-01851661
https://hal.science/hal-01851661
Submitted on 30 Jul 2018

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# Mathematical model of dropwise condensation on textured surfaces 

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## Introduction

- General issue: formation of water droplets in foggy days on interior side of car light shields.
- Idea for solving the problem: applying different texturing patterns on the vitreous substrate to control the rate of droplets growth.


Figure: Formation of water droplets (because of dropwise condensation) on car light shields reduces light reflection in foggy days.

## Dropwise condensation

The process of dropwise condensation consists of five main steps:

- nucleation of initial droplets
- growth rate due to adsorption
- growth rate due to coalescence
- nucleation of new small droplets
- sliding very big droplets from the surface.


## Flat v.s textured substrates

The most important difference between droplets on flat and textured substrates: their geometry:


Figure: (a) Spherical droplets on the flat, (b) elliptical droplets on the sinusoidal substrates.
Equation of sphere: $\frac{1}{r^{2}}\left(X-X_{0}\right)^{2}+\frac{1}{r^{2}}\left(Y-Y_{0}\right)^{2}+\frac{1}{r_{1}^{2}}\left(Z-Z_{0}\right)^{2}=\mathbf{1}$
Equation of ellipsoid: $\frac{1}{a^{2}}\left(X-X_{0}\right)^{2}+\frac{1}{b^{2}}\left(Y-Y_{0}\right)^{2}+\frac{1}{c^{2}}\left(Z-Z_{0}\right)^{2}=1$

## Mathematical modeling

Aim: improving the existing models regarding circular droplets ([1]) for elliptical ones. Adsorption of ellipsoidal droplets:


$$
\begin{equation*}
a_{k}=a_{k-1}+\frac{\mathrm{d} a}{\mathrm{~d} t} \tag{1}
\end{equation*}
$$

where $k$ represents the time step. For $\boldsymbol{b}$ and $c$ the same equation can be written. $\frac{d a}{d t}$ is the growth rate and can be calculated from adsorption laws.


## Conclusions

- we presented a mathematical model for simulating ellipsoidal droplets growth on textured substrates.
- The presented model is applied to 6 different pillared surfaces and its mean error is calculated on all the surfaces of about $\mathbf{1 0 \%}$ for droplets density and $\mathbf{2 \%}$ for droplets size.


## Acknowledgements

This work was funded by LABEX MANUTECH-SISE (ANR-10-LABX-0075, within the program "Investissements dAvenir" (ANR-11-IDEX-0007) operated by the French National Research Agency (ANR).

## References

[1] S. Boroomandi Barati, J.C. Pinoli, S. Valette, Y. Gavet, "Investigation spatial distribution of droplets and the percentage of surface coverage during dropwise condensation", International Journal of Thermal Sciences. 124 (2018), 356-365. [2] L. Glicksman, A. Hunt, "Numerical simulation of dropwise condensation", International Journal of Heat and Mass Transfer. 15 (1972), 2251-2269.

