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Review

Review of drop impact on heated walls

Gangtao Liang [a,b], Issam Mudawar [b,*]

[a] Key Laboratory of Ocean Energy Utilization and Energy Conservation of Ministry of Education, School of Energy and Power Engineering, Dalian University of Technology, Dalian 116024, China
[b] Purdue University Boiling and Two-Phase Flow Laboratory (PU-BTPFL), School of Mechanical Engineering, 585 Purdue Mall, West Lafayette, IN 47907, USA

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ABSTRACT

This paper provides a comprehensive review of published literatures concerning the fluid mechanics and heat transfer mechanisms of liquid drop impact on a heated wall. The review is divided into four parts, each centered on one of the main heat transfer regimes: film evaporation, nucleate boiling, transition boiling, and film boiling. Each of these regimes is discussed in detail in terms of available depictions of drop deformation and/or breakup, proposed heat transfer mechanisms, predictive correlations and/or models. It is shown that understanding the underlying physics for each heat transfer regime is highly dependent on the experimental methods that investigators have adopted, and broadness of available databases in terms of liquid type, drop size and momentum, impact angle, and wall material and surface roughness. Despite significant advances in experimental, theoretical and computational research in understanding the interfacial behavior of the drop from the moment of impact, there are many inconsistencies concerning some of the most important aspects of the impact process and ensuing heat transfer, especially in regards to critical heat flux, transition boiling, and the Leidenfrost point. This review is concluded with recommendations concerning future work that is needed to address poorly understood and/or contradictory issues.

Contents

* Corresponding author.
E-mail address: mudawar@ecn.purdue.edu (I. Mudawar).
URL: https://engineering.purdue.edu/BTPFL (I. Mudawar).

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Nomenclature

Bo	bond number
C	coefficient
c_p	specific heat at constant pressure
D	spreading diameter
d	diameter
D^*	non-dimensional spreading diameter
d_{32}	Sauter Mean Diameter
g	gravitational acceleration
h	heat transfer coefficient
h_c	convective heat transfer coefficient
h_{fg}	latent heat of vaporization
h^*_{fg}	modified latent heat of vaporization
Ja	Jacob number
k	thermal conductivity
m	defect size
N	number of secondary droplets
n	exponent
Nu	Nusselt number
Oh	Ohnesorge number
P	pressure
Pr	Prandtl number
Q	heat transfer rate
q''	heat flux
R	radius of wetted area
r	radial coordinate
Re	Reynolds number
R_a	average surface roughness
R_z	height of surface roughness feature
T	temperature
t	time
V	drop volume
v	velocity
v^*	dimensionless velocity
v_{sound}	speed of sound in liquid
We	Weber number
x	vapor molar fraction
z	axial coordinate

Greek symbols

α	thermal diffusivity; average ejection angle of secondary droplets
β	coefficient
δ	vapor layer thickness
δ^*	dimensionless vapor layer thickness
ε	mass diffusivity
μ	viscosity
ϕ	impact angle
ρ	density
σ	surface tension
τ	non-dimensional time
θ	contact angle
θ_r	receding contact angle
θ_0	initial contact angle

Subscripts

b	drop base
c	critical
contact	liquid–solid contact
drop	liquid drop
e	evaporation
f	liquid
g	gas
i	interface; inclined
L	Leidenfrost
L, d	dynamic Leidenfrost
L, i	dynamic Leidenfrost for inclined impact
max	maximum
n	normal
min	minimum
o	oscillation
r	residence
sat	saturation
v	vapor
w	wall