UC Berkeley
UC Berkeley Previously Published Works

Title

Optimizing Rotary Bell Atomization

Permalink

https://escholarship.org/uc/item/4c88279v

Authors

Saye, R
Nugent, P

Publication Date

2020-03-19

Peer reviewed

eScholarship.org Powered by the California Digital Library
University of California

CRADA Final Report Form

Date: __03/18/2020_________________

PI: Peter Nugent

CRADA AWD No.: AWD00002200 **CRADA FP No.:** FP00005092

LBNL Report Number: __________________

OSTI Number: ________________________ *(SPO to add)*

1. Parties: PPG Industries
   (Identify Parties to the CRADA)

2. Title of the Project: HPC4Mfg with PPG

3. Summary of the specific research and project accomplishments:

   The goal of this project is to design, develop, and validate a customized high performance computing (HPC) numerical framework to study rotary bell atomization, a key manufacturing process used in industry to spray and apply paints. Optimizing the atomization process for higher paint flow rates would allow industry to accelerate the assembly line, reduce energy consumption, and increase throughput while maintaining coat thickness and high quality appearance. Accurately modeling this process requires a combination of advanced HPC and computational fluid dynamics to significantly advance the state of the art. The developed numerical framework will be used to study the rotary bell atomization process as a function of paint fluid properties, film thickness, and bell geometry at scales and parameters relevant to industrial conditions.

   The combined experimental findings and insight from 2D and 3D numerical modeling enabled progress to be made in the understanding of the key physics driving the rotary bell atomization process. Accomplishments include improved understanding of: (i) the relative strengths of inertial, viscous, centrifugal, and surface tension forces in the overall atomization process; (ii) the source and role of non-uniform film thicknesses on the inside surface of the cup; (iii) dependence of sheeting behavior on film thicknesses at the edge of the cup; and (iv) formation of tendrils and their subsequent breakup into droplets.

4. Deliverables:

Deliverables met	Party (LBNL,	Delivered to

	Participant, Both)	Other Party?
Interim reports	LBNL	Yes
Final technical report	LBNL and PPG	Yes
Experimental rheological parameters and case studies	PPG	Yes
Simulation results	LBNL	Yes

5. Identify (list below) and attach all publications or presentations at conferences directly related to the CRADA:

   N/A

6. List of Subject Inventions and software developed under the CRADA: (Please provide identifying numbers or other information.)

   N/A

7. A final abstract suitable for public release: (Very brief description of the project and accomplishments without inclusion of any proprietary information or protected CRADA information.)

   In our LBNL, PPG Industries collaboration, we designed, developed, and validated a customized high performance computing (HPC) numerical framework to study rotary bell atomization, a key manufacturing process used in industry to spray and apply paints. Optimizing the atomization process for higher paint flow rates would allow industry to accelerate the assembly line, reduce energy consumption, and increase throughput while maintaining coat thickness and high quality appearance. Accurately modeling this process requires a combination of advanced HPC and computational fluid dynamics to significantly advance the state of the art. The developed numerical framework has been used to study the rotary bell atomization process as a function of paint fluid properties, film thickness, and bell geometry at scales and parameters relevant to industrial conditions. The combined experimental findings and insight from 2D and 3D numerical modeling enabled progress to be made in the understanding of the key physics driving the rotary bell atomization process. Accomplishments include improved understanding of: (i) the relative strengths of inertial, viscous, centrifugal, and surface tension forces in the overall atomization process; (ii) the source and role of non-uniform film thicknesses on the inside surface of the cup; (iii) dependence of sheeting behavior on film thicknesses at the edge of the cup; and (iv) formation of tendrils and their subsequent breakup into droplets.

8. Benefits to DOE, LBNL, Participant and/or the U.S. economy.

Successfully modeling the rotary bell paint process addresses a key challenge in manufacturing and supports the goals of the HPC4Mfg program by: 1) enabling industrial manufacturers to reduce cycle time and energy consumption; 2) bringing together a major US manufacturer with an HPC facility for an applied research collaboration that would not have occurred without this program, resulting in heightened HPC adoption; and 3) enabling development of next generation coatings optimized for high throughput applications and accelerating their adoption in paint lines across industries. There are four ways in which the joint work benefits both LBNL and the DOE mission. First are the particulars of the problem at hand: understanding and building a high order accurate mathematical and algorithmic framework to accurately compute droplet dynamics in complex settings will provide insight to a host of DOE-related scientific interests, including, for example, spray mechanisms and microscale fluid injection in combustion. Second, new algorithmic technologies developed as part of the research required to execute this investigation, including our work on hybrid DG + finite difference methods and new multigrid methods for DG, should have applicability to a host of other DOE-supported projects, including accurate modeling of wind turbines and groundwater transport in complex structures. Third, there is a clear pathway for much of this work to DOE exascale applications, through collaborations with LBNL's CCSE. Fourth, the joint experimental-computational work to establish reliable and tractable models for non-Newtonian fluid will have a wide spectrum of applications in such areas as modeling rheologically complex fluids.

9. Financial Contributions to the CRADA:

DOE Funding to LBNL	$300,000
Participant Funding to LBNL	$0
Participant In-Kind Contribution Value	$106,000
Total of all Contributions	$406,000

* *"Proprietary Information" means information, including data, which is developed at private expense outside of this CRADA, is marked as Proprietary Information, and embodies (i) trade secrets or (ii) commercial or financial information which is privileged or confidential under the Freedom of Information Act (5 U.S.C. 552 (b)(4)).*