Internal Surface Treatments to Help Decarbonize Industrial Cleaning Processes

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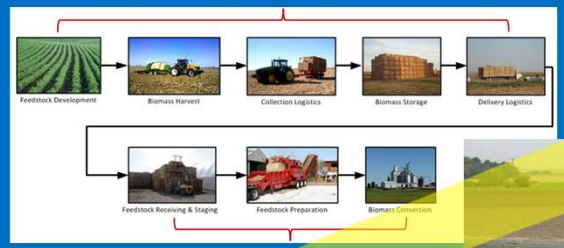
NOT Selected Submissions

Manufacturing Liquid Fuel In-Situ from Biomass

Mobile biomass to biofuel machine …

- Produces liquid fuel by fast pyrolysis
- Mitigates inefficiency of low-density biomass processing and transport
- Reduces fuel for wildfires

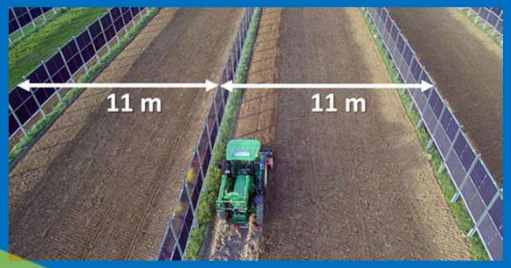


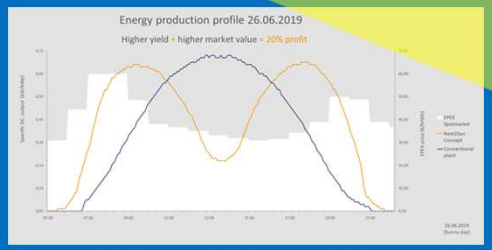
Develop machine to combine processes similar to =>

Manufacturing of Integrated Photovoltaic and Agricultural Systems

Vertical bifacial solar cells facing east-west…

- Maintain agronomic production
- Allow high agricultural operation efficiencies
- Complement conventional photovoltaics





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Personal Motivation:

As a teenager, at 5:00 a.m., 7:00 a.m., 5:00 p.m., and 7:00 p.m. on 365 days/year, I had to CIP (Clean In Place) over 200 feet of stainless steel pipe interiors.

Over 34,000 dairy farms

- CIP twice or thrice a day
- hot water 25% of dairy farm total energy use
- hot water 20% of fluid milk plant energy use

Cleaning important elsewhere

- Over 34,000 food and beverage
- Other industries

Cleaning Also Very Important in Retail Industry

Example: McDonald's Soft-Serve Machines

"The Taylor ice cream machine takes four hours to clean and sanitize itself — and the process needs to be completed every single day.

…

Instead of finding a clean machine ready to serve ice cream, the employees find a machine boasting an error message telling them that it didn't clean properly and will need to be cleaned again. The kicker? The error message doesn't say what went wrong, just that it needs to try cleaning again."

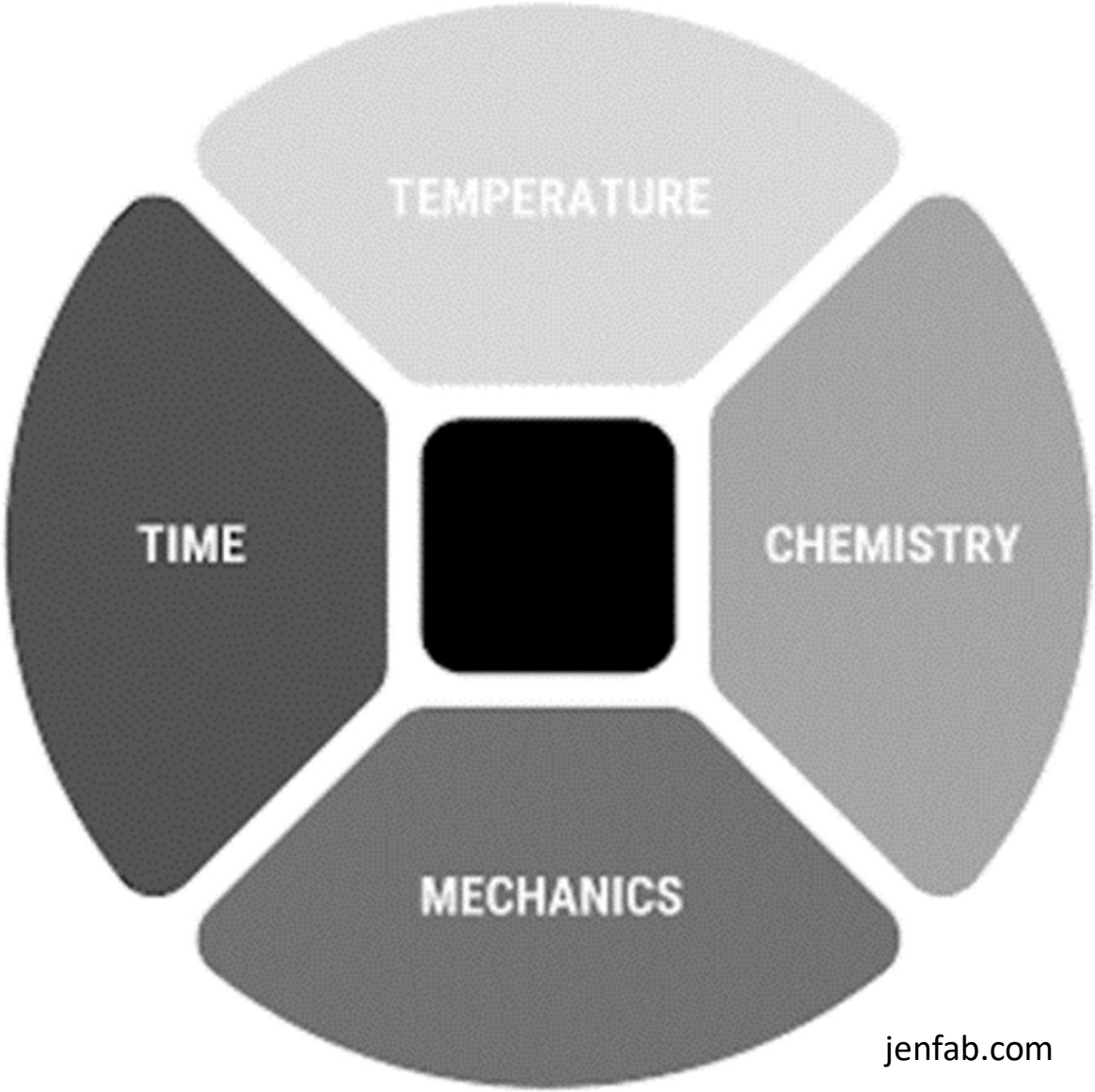
https://www.allrecipes.com/article/the-real-reason-mcdonalds-ice-cream-machines-are-always-broken/

Sinner's Circle

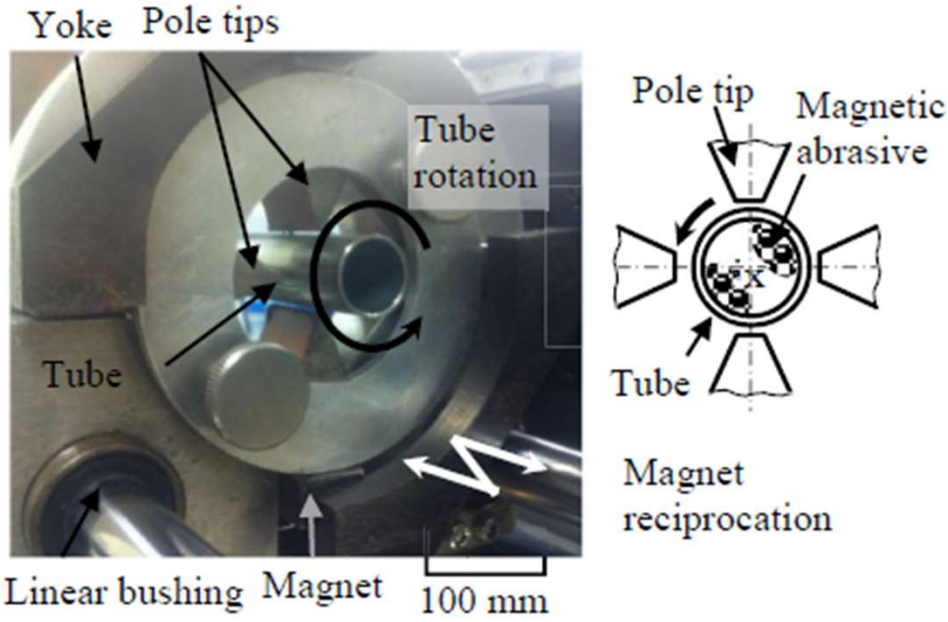
"Mechanics" usually agitation or impingement

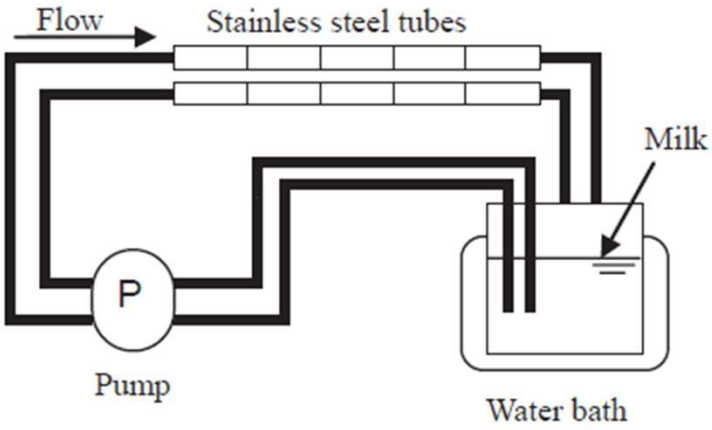
But can also include the surface

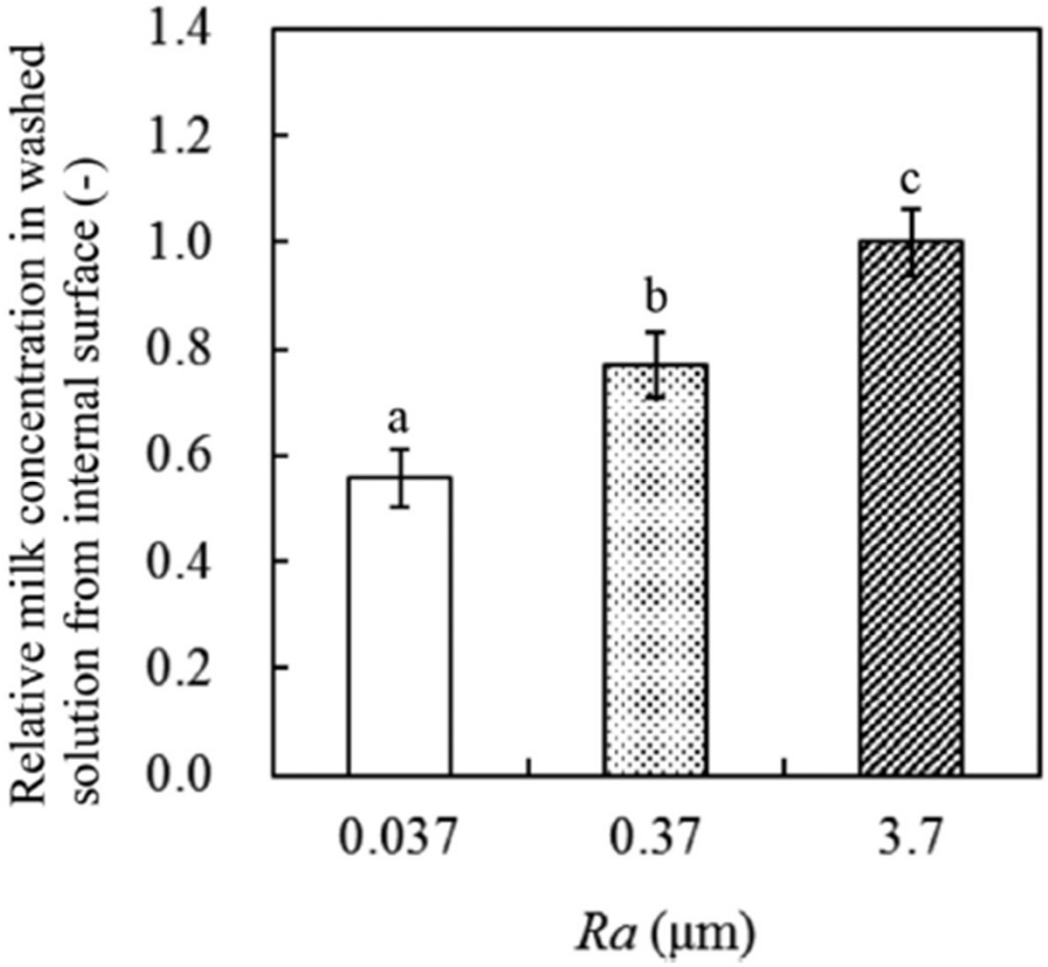
We are making and testing smoother surfaces to improve cleaning



jenfab.com







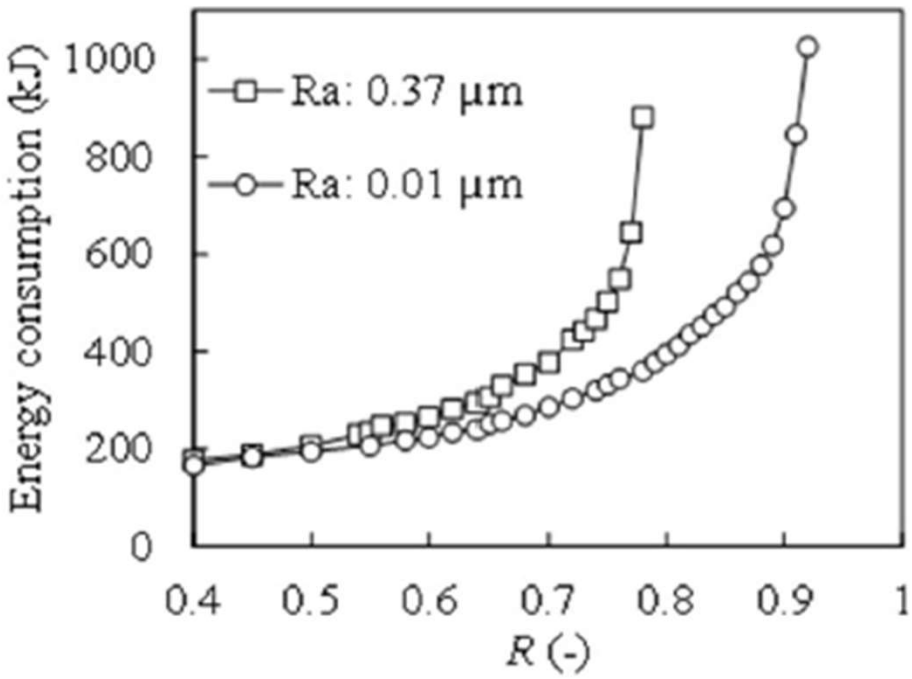
Ihara, et al., *Engineering in Agriculture, Environment and Food*. 10(2017):63-68

Energy Consumption

Dominated by water heating (not pumping)

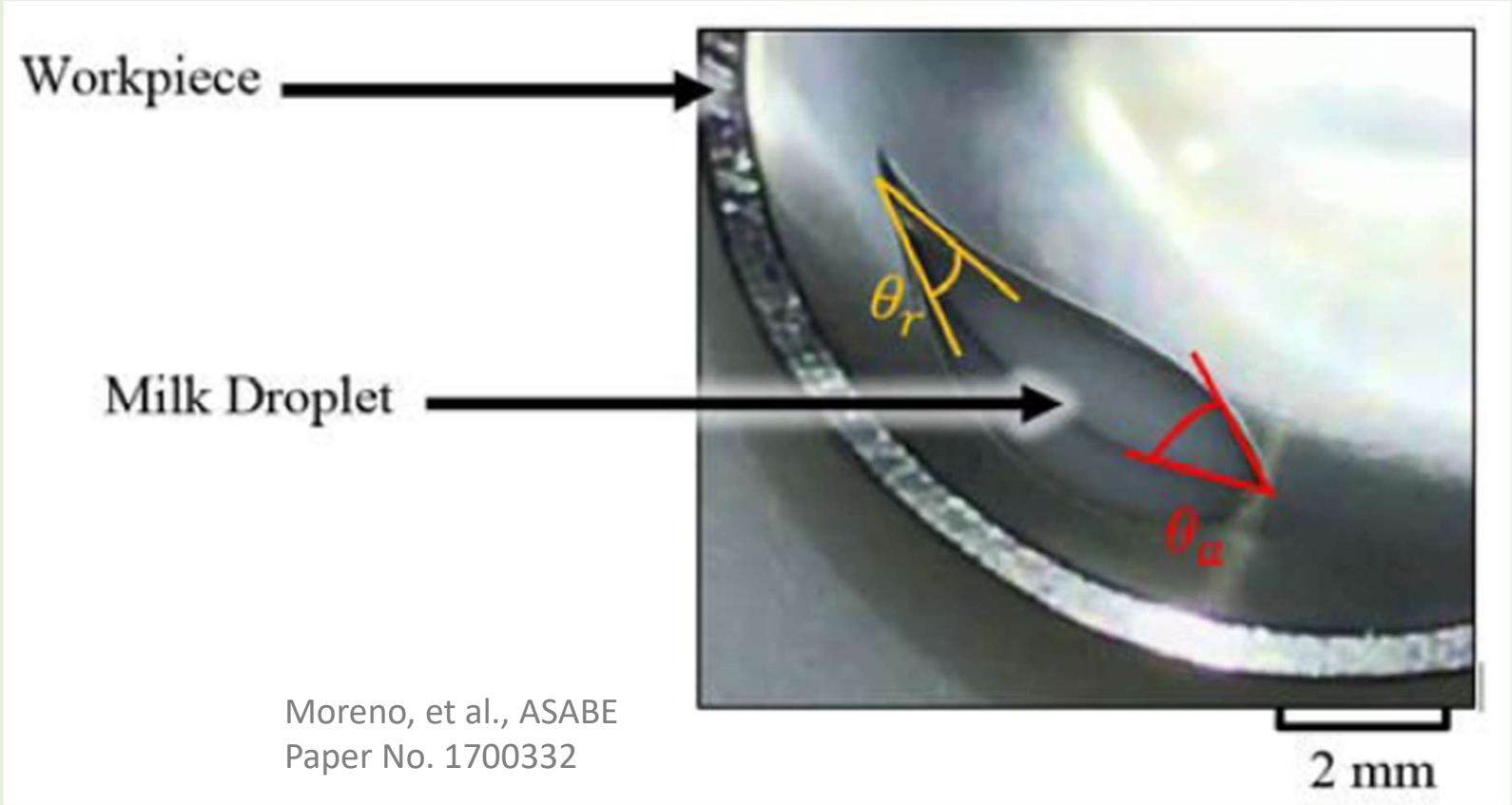
Smoother surfaces are cleaned easier

Requires less hot water



R = cleanliness level
(higher is cleaner)

Rotating tubes smoother than R_z = 0.5 µm had lower contact hysteresis angles



Moreno, et al., ASABE Paper No. 1700332

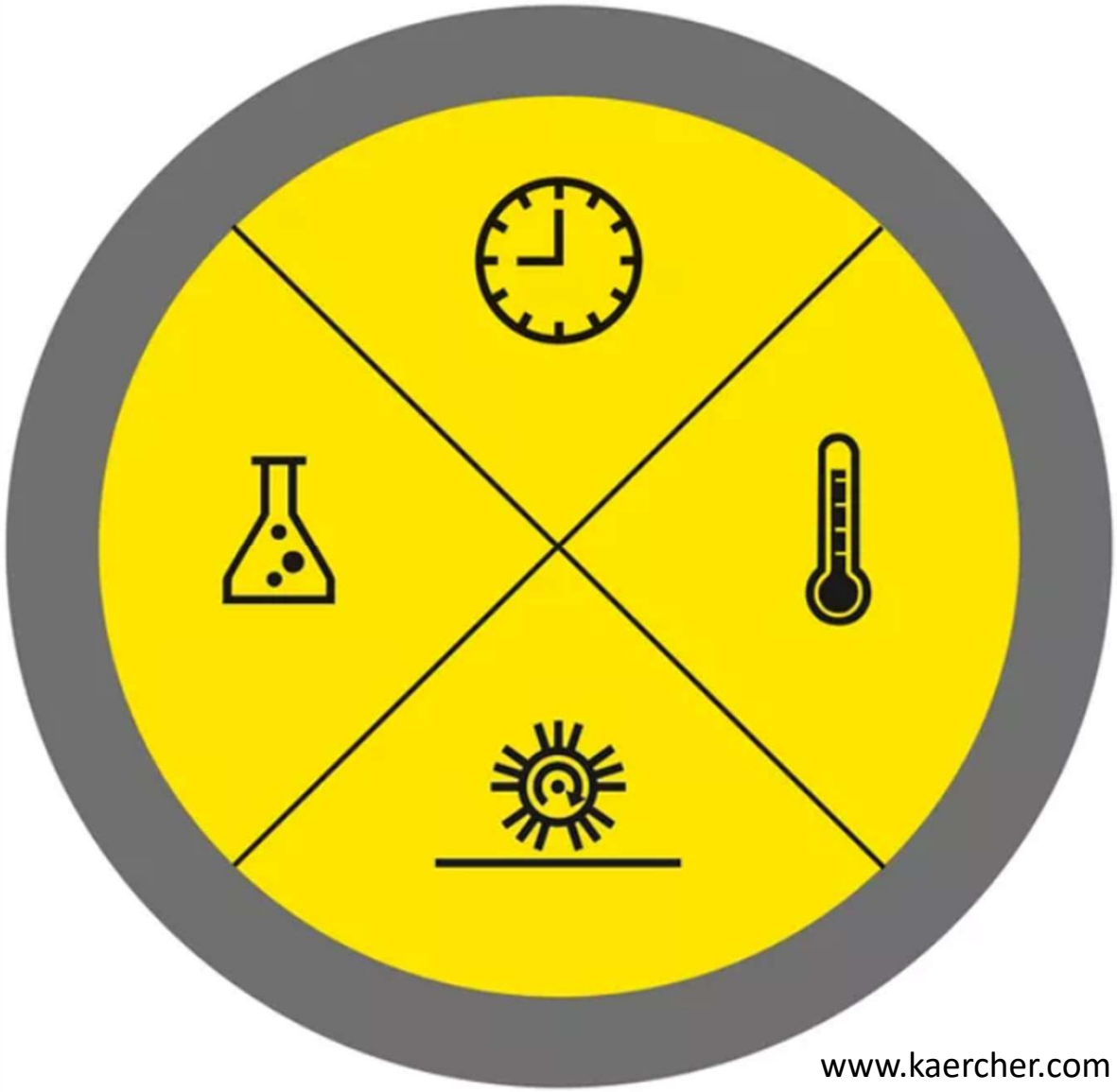
Better Understanding Needed

Processes

- Deposition
- Removal/Cleaning

Factors

- Time
- Temperature
- Chemistry
- Mechanics



www.kaercher.com

To minimize

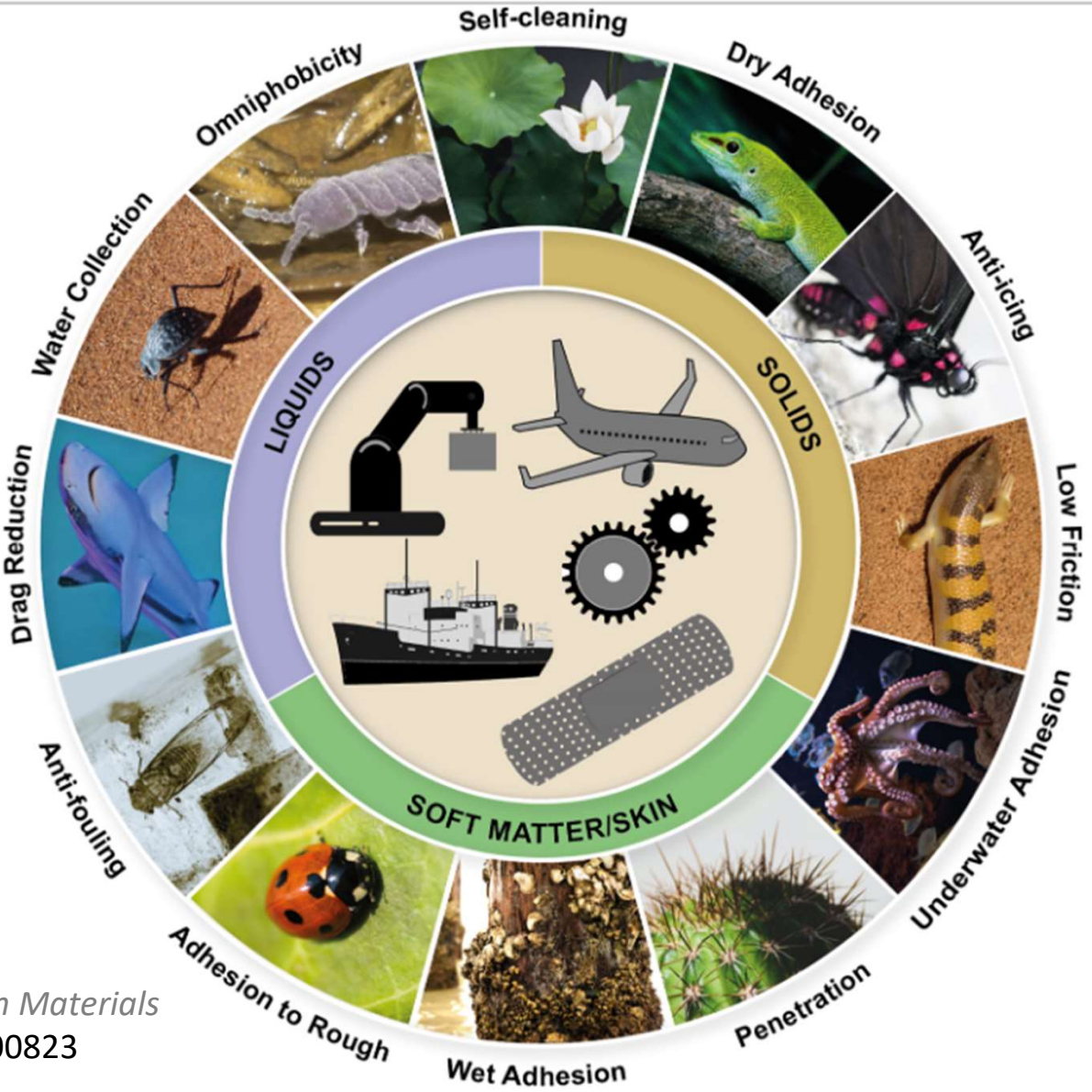
- Total lifetime costs
- Total lifetime environmental impacts

We need to…

- Minimize water usage
- Minimize detergent usage
- Minimize energy usage
- Manufacture efficiently

After improving smooth surface cleaning, we need to develop more effective functional surfaces

Functional surfaces may help fight fouling and promote cleaning



Arzt, et al., *Progress in Materials Science*. 120(2021):100823

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