A mapping approach for 3D distributive mixing flows
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Objective
Study and optimize properties of industrial mixing flows.

Mapping method
The idea is not to track each material volume in the flow domain separately, but to create a discretized mapping from a reference grid to a deformed grid.
- Flow domain \( \Omega \) is subdivided into \( n \) non-overlapping sub-domains \( \Omega_i \), with boundaries \( \Gamma_i \).
- \( \Gamma_i \)'s are covered by an unstructured surface mesh and subsequently tracked from \( t = t_0 \) to \( t = t_0 + \Delta t \) using an adaptive front tracking technique.
- Intersections of the deformed and original sub-domains determine the elements of the mapping matrix \( \Phi \).

Concentration distributions
Dependence of the mixing efficiency of the protocol \( F_{a,b}, F_{b,c}, F_{c,d} \) on the dimensionless displacement. The energy input in all cases is the same.

Concentration in the transport section of a twin screw extruder. The figures illustrate the filling of the extruder.

Twin screw extruder
Basic types of twin screw extruder elements. From left to right: conveying element, counter conveying element, conveying kneading section, neutral kneading section and counter conveying kneading section.

Mapping computation for twin screw extruder

Mapping Matrix Properties

<table>
<thead>
<tr>
<th>property</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>( n_x \times n_y \times n_z )</td>
<td>184 \times 100 \times 48</td>
</tr>
<tr>
<td># subdomains</td>
<td></td>
</tr>
<tr>
<td>Full matrix size</td>
<td>1,766, 400 \times 883, 200</td>
</tr>
<tr>
<td>(( \approx 1.56 \times 10^{22} ))</td>
<td></td>
</tr>
<tr>
<td>non-zero elements</td>
<td>13,011, 100</td>
</tr>
<tr>
<td>matrix density</td>
<td>8.34 \times 10^{-8}</td>
</tr>
<tr>
<td>CPU time</td>
<td>&gt; 1 year</td>
</tr>
</tbody>
</table>

Future work
- Mapping technique can be used to investigate different configurations of mixer devices (for twin screw extruders — different sequence of screw elements of different type).
- Multiscale extended mapping approach (mapping with modelling of microstructure development) can be extended for complex 3D flows.

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