# Solid suspension in viscoelastic media: manufacturing challenges




- High viscosity
- Non-Newtonian rheology (viscoelasticity)

**Energy waste**

- Long mixing time
- Higher minimum mixing speed

**Reduced mixing quality**

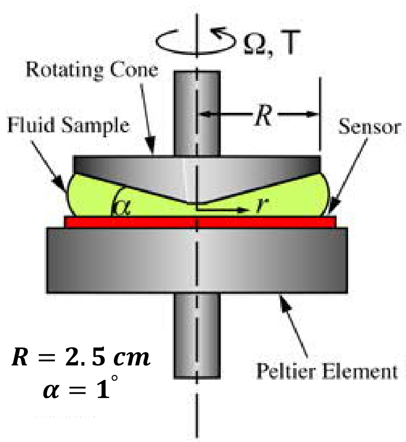
- Formation of caverns
- Clustering
- Dead volumes

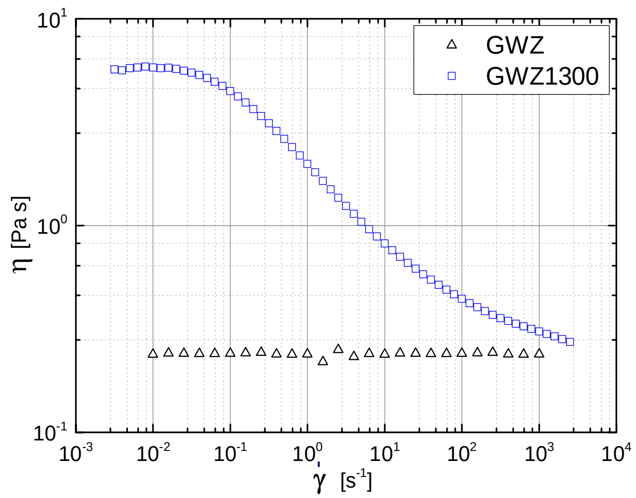
## Outline

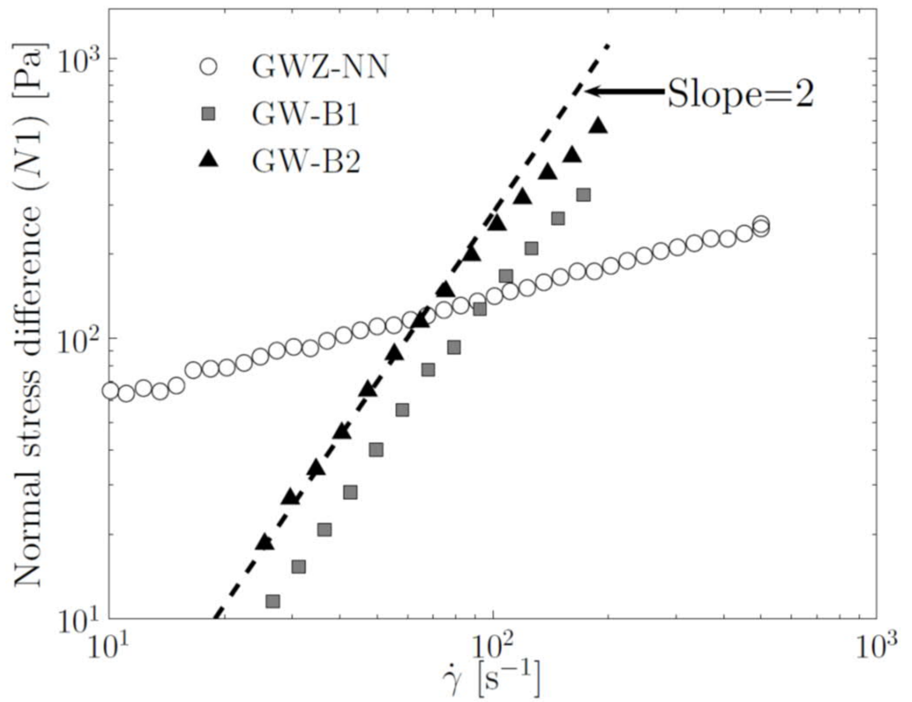
- Rheological characterization
- Results
  - Newtonian
  - Non-Newtonian
  - Clustering time
- Conclusions and Future work

# Rheological characterization

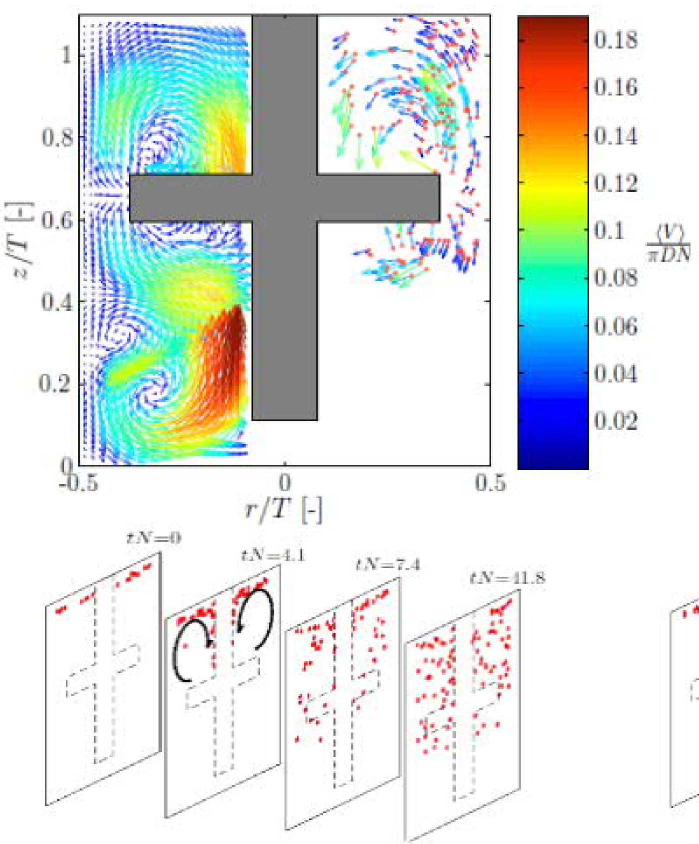
| Acronym | Polymer | ρ $[Kg/m^3]$ | μ $[Pa\ s]$ | $r_n$ |
|---|---|---|---|---|
| **PMMA** | - | 1180 | - | 1.489 |
| **GWZ-N** | - | 1630 | 0.25 | 1.487 |
| **GWZ-NN** | 0.13% Xanthan gum | 1630 | ST | 1.487 |
| **GW** | - | 1250 | 0.85 | 1.475 |
| **GW-B1** | 100 ppm PAA | 1250 | 0.85 | 1.475 |
| **GW-B2** | 200 ppm PAA | 1250 | 0.85 | 1.475 |



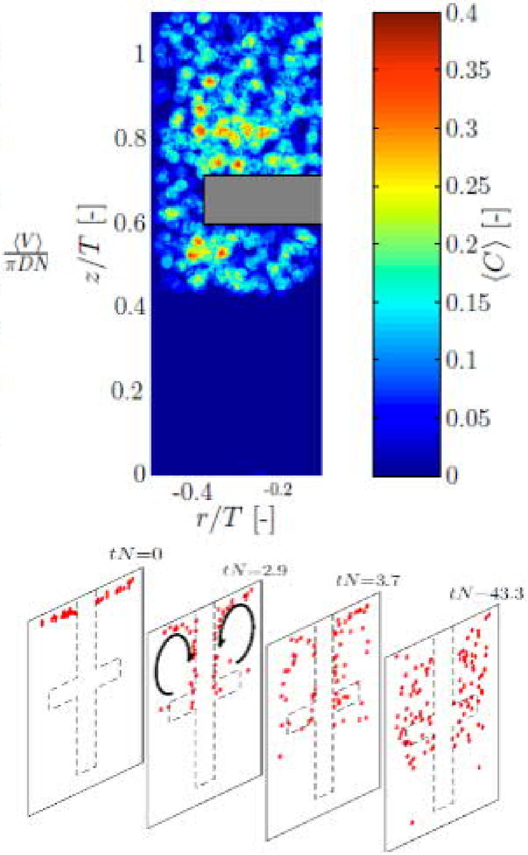



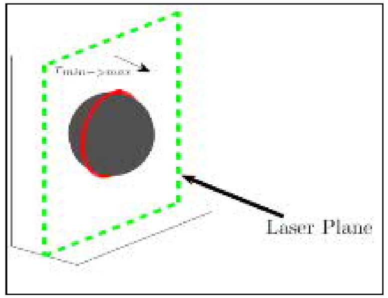
# Results – Newtonian (GWZ)



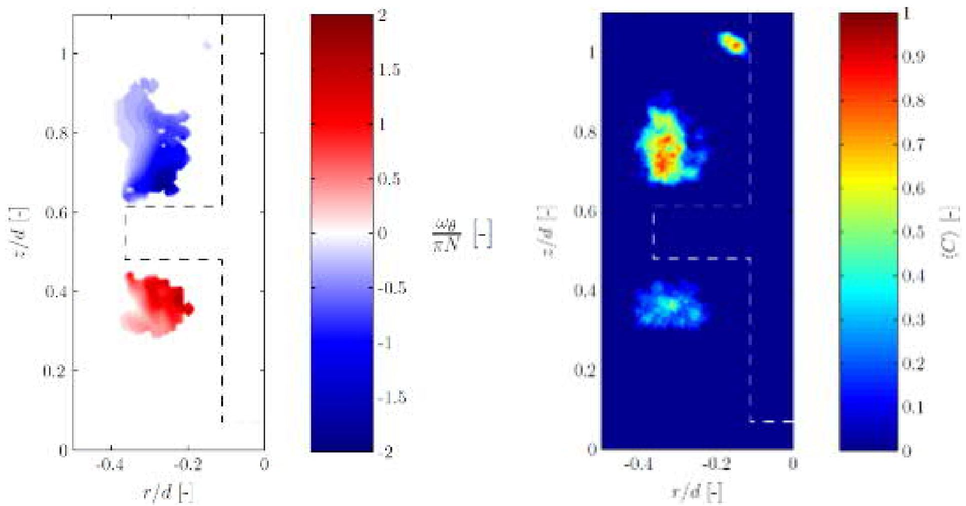

$$\boldsymbol{Re = 59}$$



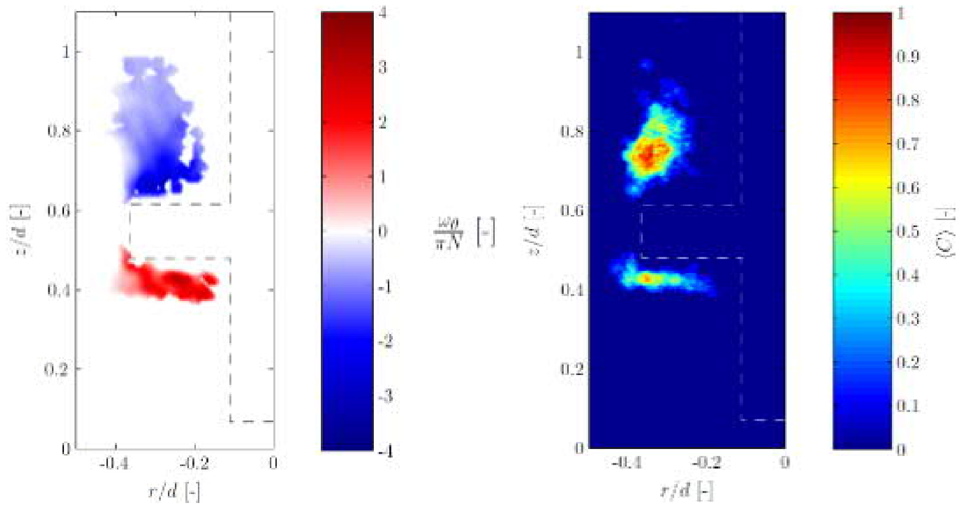

$$\boldsymbol{Re = 90}$$




$$\frac{u\_slip}{u_L} = \left|\frac{u_s - u_L}{u_L}\right| \approx 10^{-2}$$

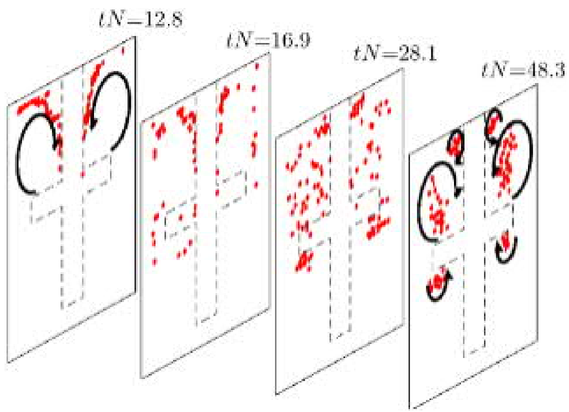


r/d [-]
z/d [-]
$\frac{\omega_\theta}{\pi N}$ [-]
⟨C⟩ [-]

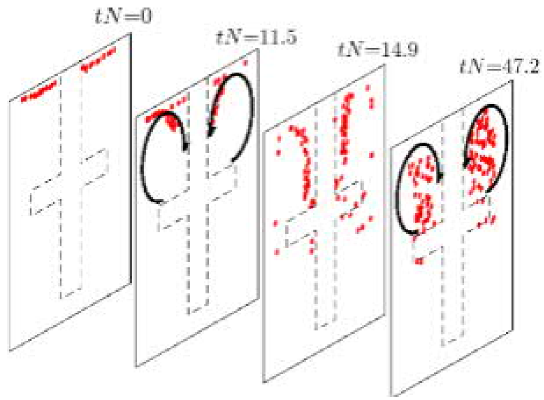
r/d [-]
z/d [-]
$\frac{\omega_\theta}{\pi N}$ [-]
⟨C⟩ [-]


**$Re = 59$**



tN=12.8
tN=16.9
tN=28.1
tN=48.3

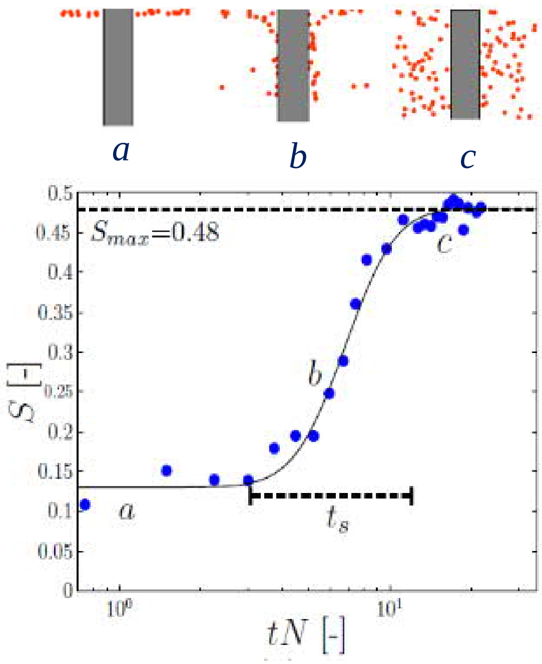

**$Re = 90$**



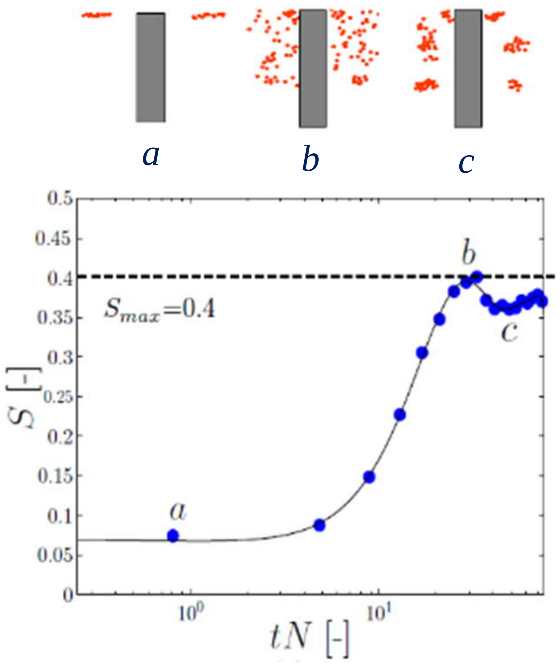
tN=0
tN=11.5
tN=14.9
tN=47.2

# Results – Viscoelasticity driven migration

$$S(t) = p(t)_S \, ln(p(t)_S) + p(t)_L \, ln(p(t)_L)$$

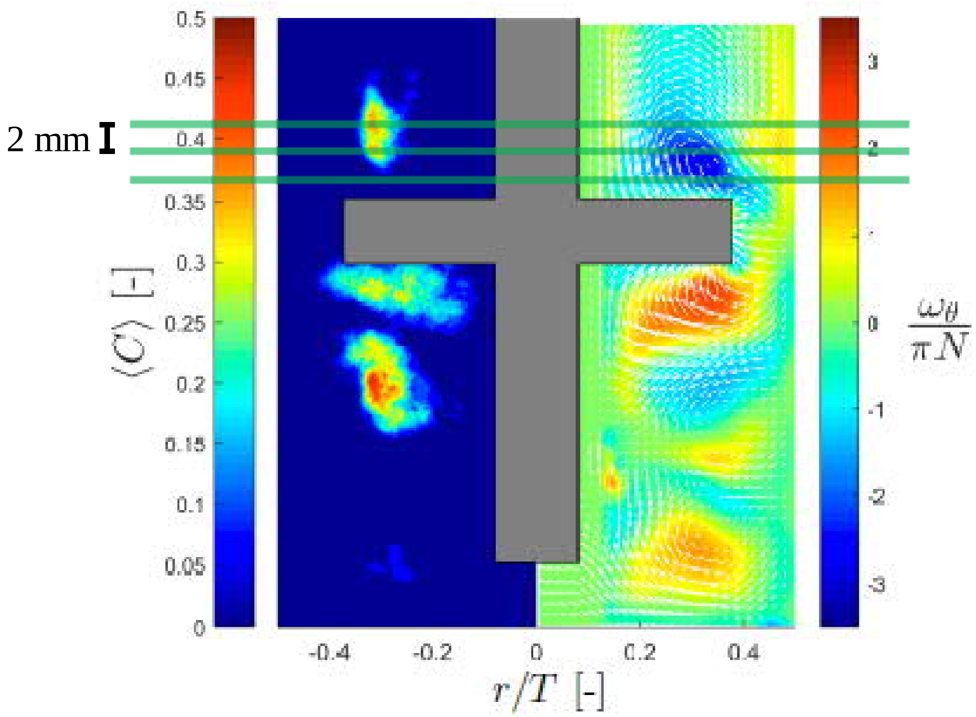


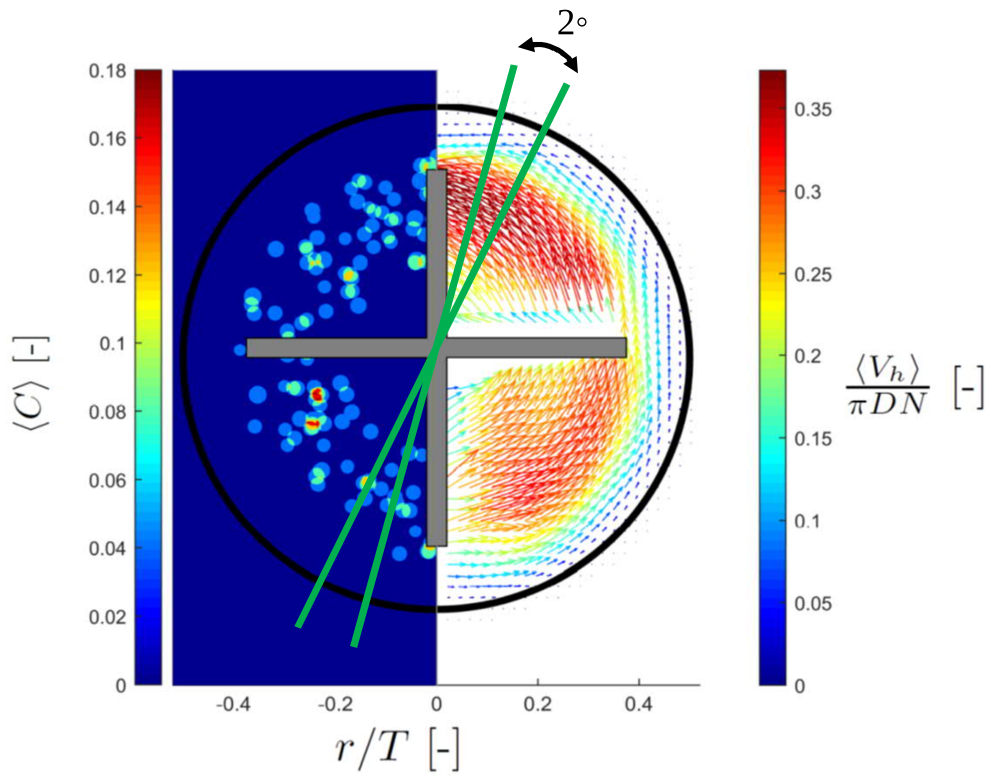

Newtonian Re=58



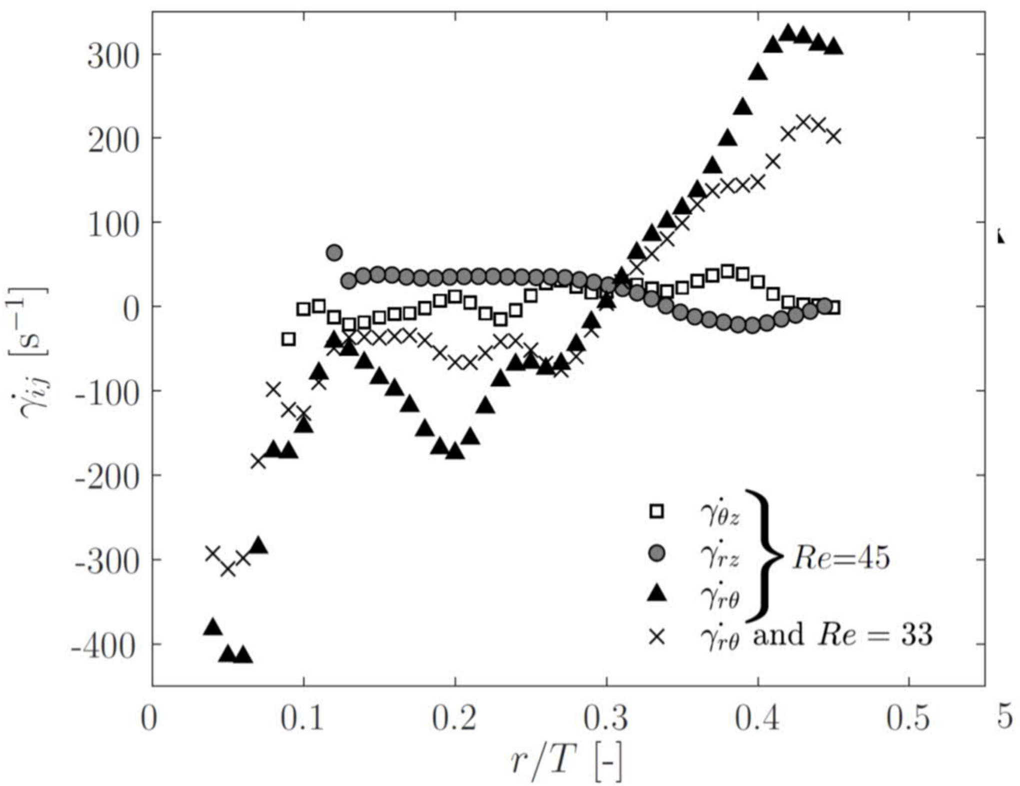

Non-Newtonian Re=58

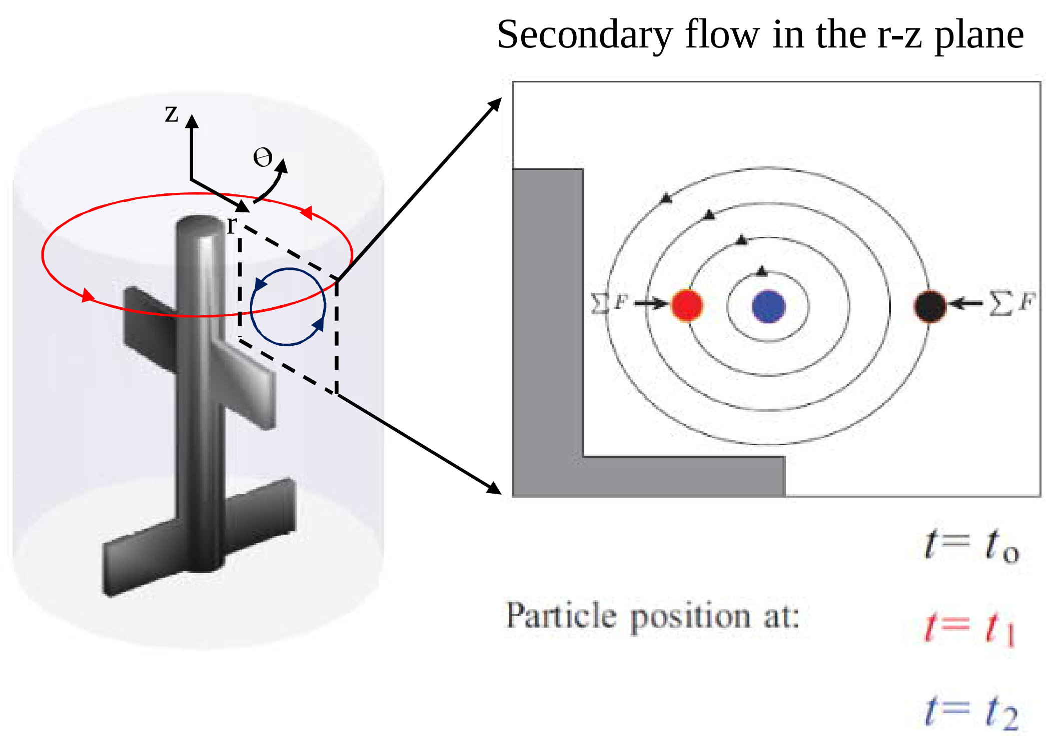
# Results – Boger fluids



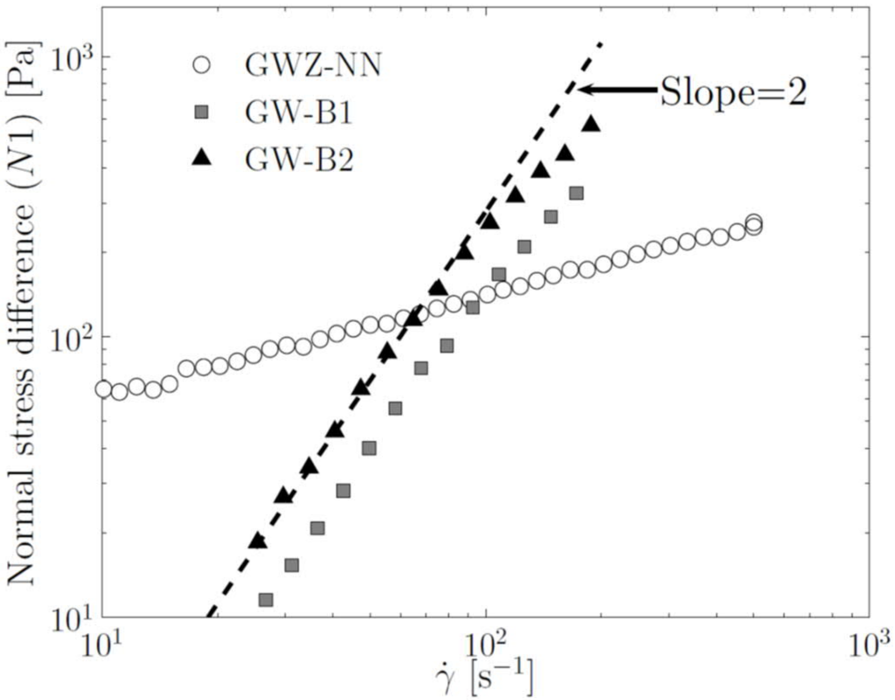



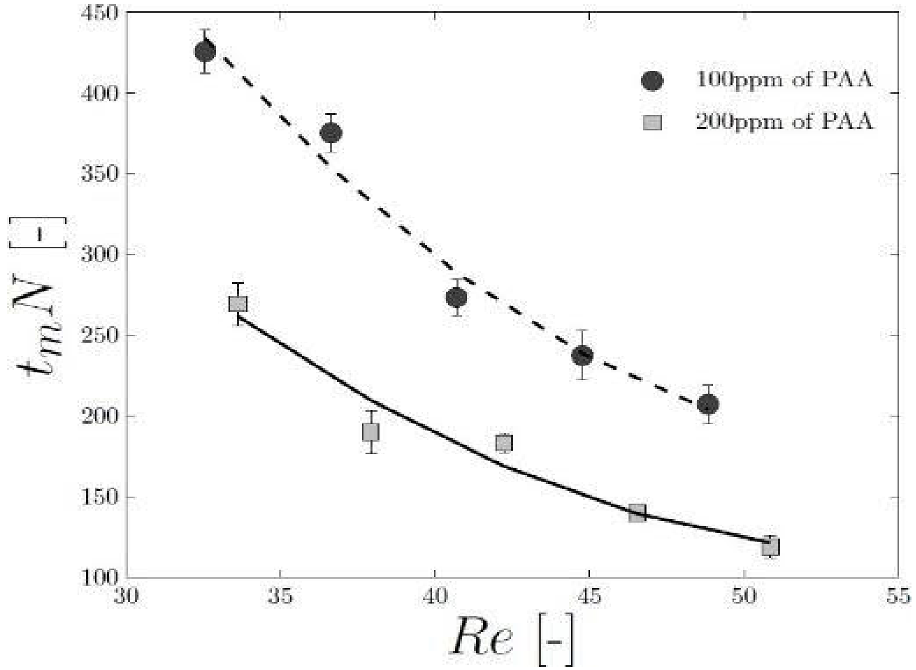
# Results – Boger fluids



# Results – Clustering time



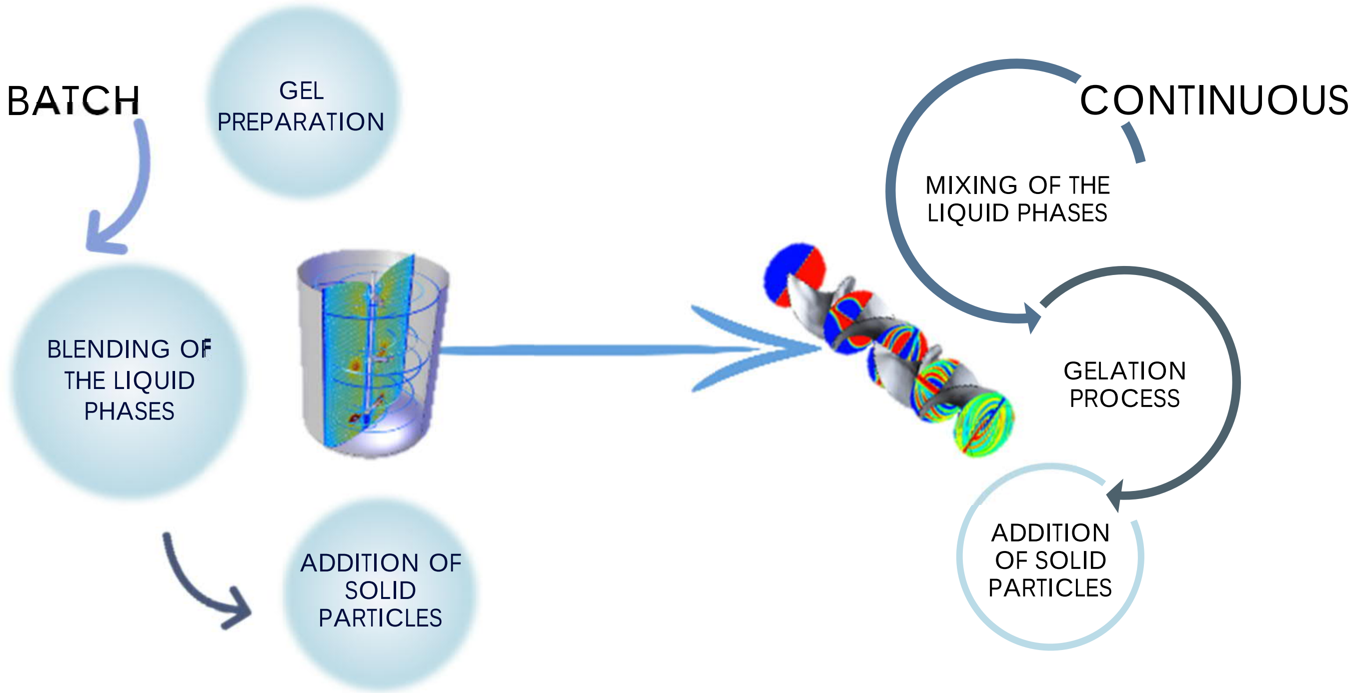
# Conclusions and Future work

## Future work

- Use a multi-phase CFD model to simulate the motion of a solid sphere in a viscoelastic fluid subjected to the 3D flow of a stirred vessel

- Decouple the suspension mechanism from the viscoelastic induced migration in order to estimate a migration velocity (migration time)

- Correlate the migration characteristic time with the rheology of the suspending fluid (scaling law)





- **W. H. Weheliye, G. Meridiano, L. Mazzei, P. Angeli, *Experimental investigation of the solid-liquid separation in a stirred tank owing to viscoelasticity*, Physical Review Fluids (2020)**