Understanding Slip Layer

Group 14

- Tiyas Maji
- Mihir Agrawal
- Tarun Goyal
- Jaya Anand
- Mrunalini Arvind Dange

Table of Contents

Introduction

In many situations, it is observed that materials of soft jammed systems glide along smooth solid surfaces, in the sense that the bulk material apparently moves as a rigid block for stress lower than the yield stress. This effect is called wall slip. Its impact on the flow characteristics is dramatic since it may make such materials, otherwise at rest, flow at a high velocity under small stresses.

Terminologies

- **No Slip BC**: Relative velocity at the solid-liquid interface is zero.
- **Slip BC**: Relative velocity at the solid-liquid interface is not necessarily zero.
- **Yield Stress**: Stress above which bulk motion begins
- **Boundary Layer**: Layer formed due to no-slip BC when a liquid flows over a surface
- **Slip Layer**: Very thin layer at the solid-liquid interface that behaves differently from the bulk behavior

Applications

01 **Microfluidics & Nanofluidics**

Due to small dimensions, no-slip BC may breakdown, making it crucial to understand slip behavior to control these systems.

02 **Oil & Gas Industry**

For the efficient transport of fluids through the pipelines it s important to understand the slip behavior

03 **Coating & Printing**

In these industries, controlling the flow and adhesion of fluids on the surface is critical. The quality of coating & printing can be affected by slip conditions.

04 **Biomedical Applications**

In the field of medicine, often slip BC is used to manipulate and analyze small amounts of biological fluids.

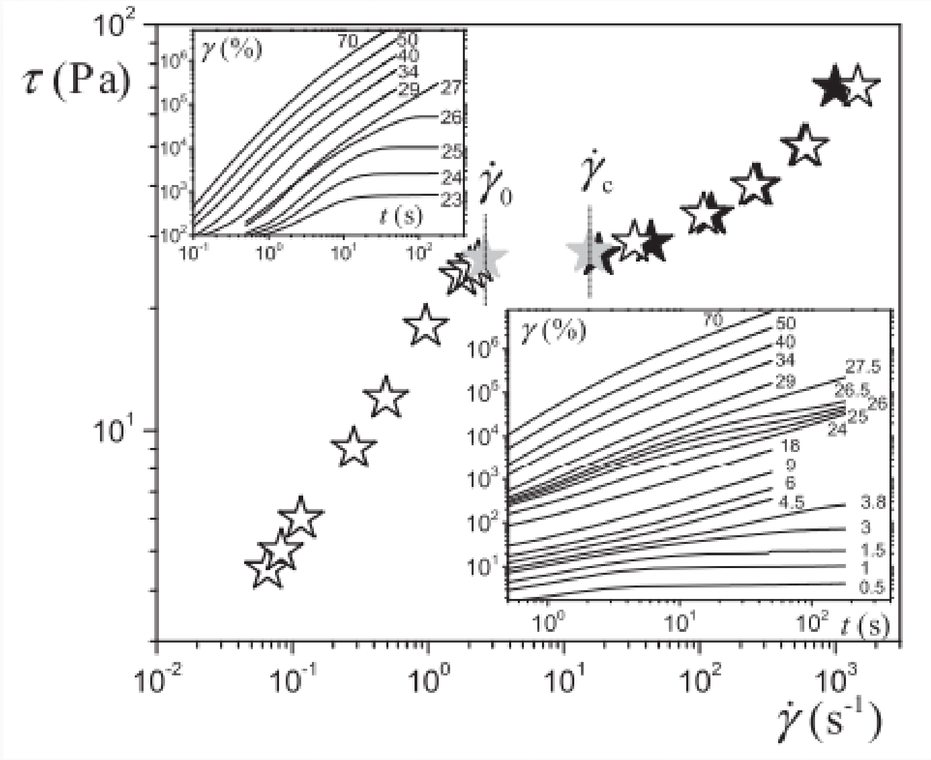
Objectives

a. Objective 1

To capture the slip layer

b. Objective 2

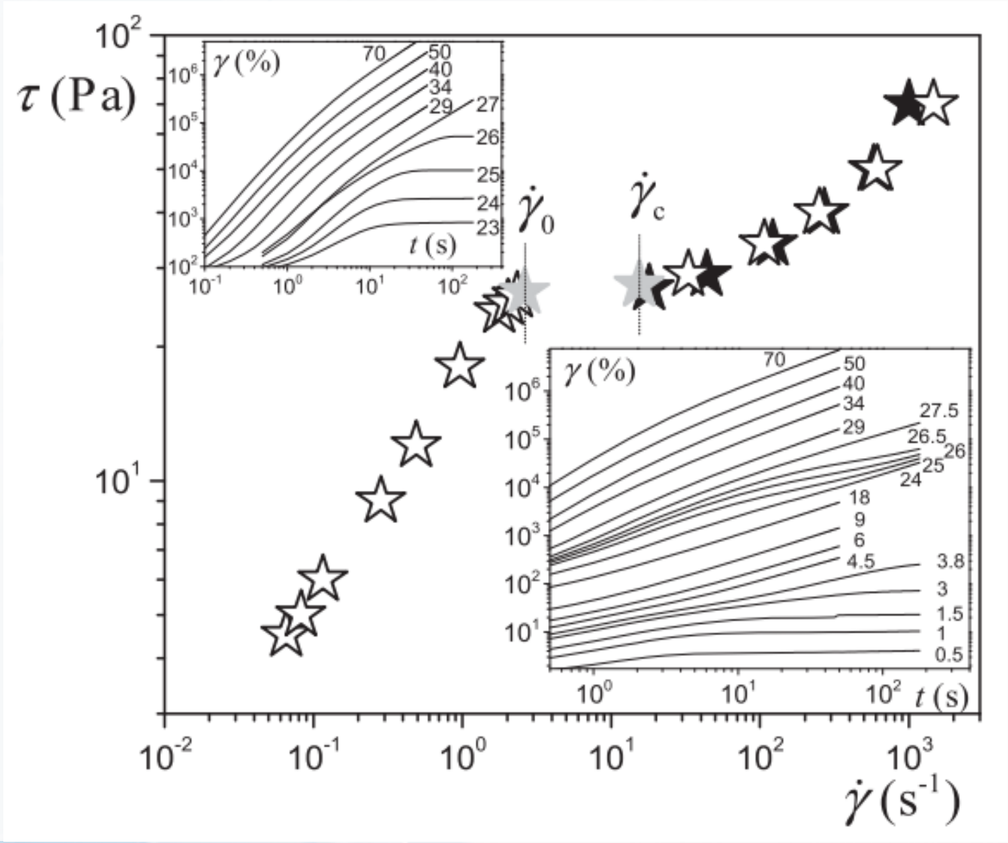
To calculate the height of the slip layer



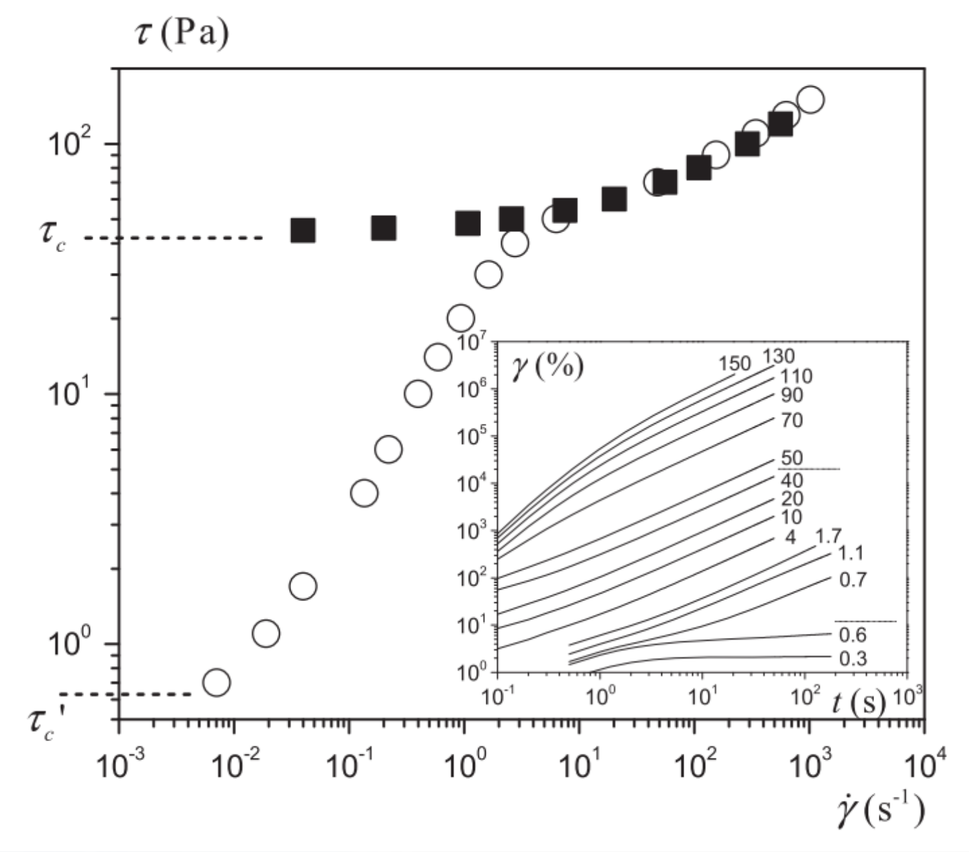
Wall Slip

When under yield stress, the bulk flows as a solid rigid body is known as wall slip, which creates a region of minimal stress and high-velocity gradient. Thus, wall slip can overturn the standard continuum mechanics description. This can be used to facilitate the transport of products such as in food digestion, coal water slurry in pipes, removal of food debris, and microbial films

stress vs strain rate



Effect of Rough vs Smooth plate



Experimental Setup

Rheometer

a. Material

Corn starch mixed with silicone oil 40 wt%

b. Set gap

1 mm

Experiment

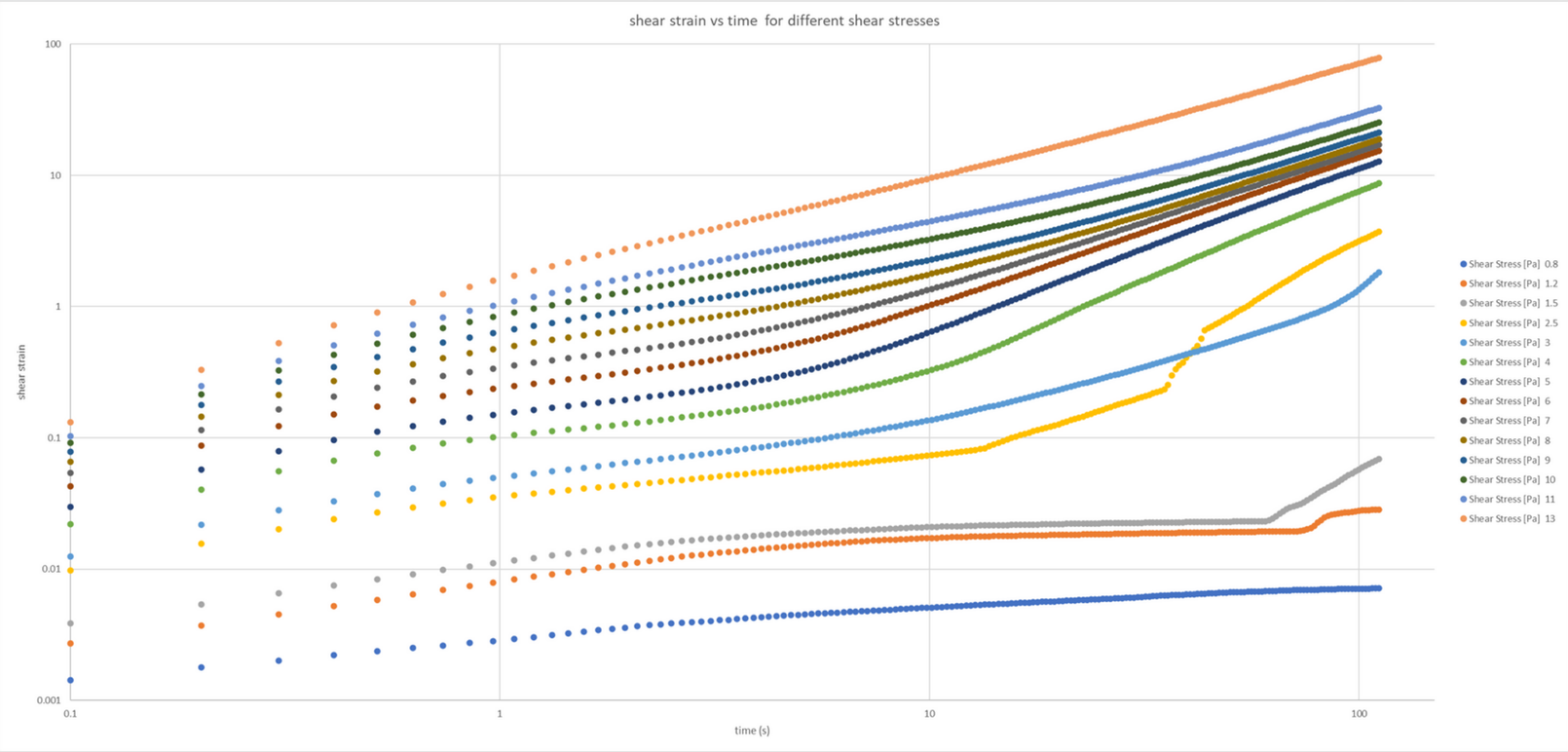
Creep Test

A creep test is a typical experiment in rheology, which studies the flow and deformation of materials, especially in response to applied forces or stresses. Creep is when a material slowly deforms over time when subjected to a constant load or stress. This deformation occurs without any sudden or immediate rupture, and it is typically a time-dependent process.

Results

Strain vs Time

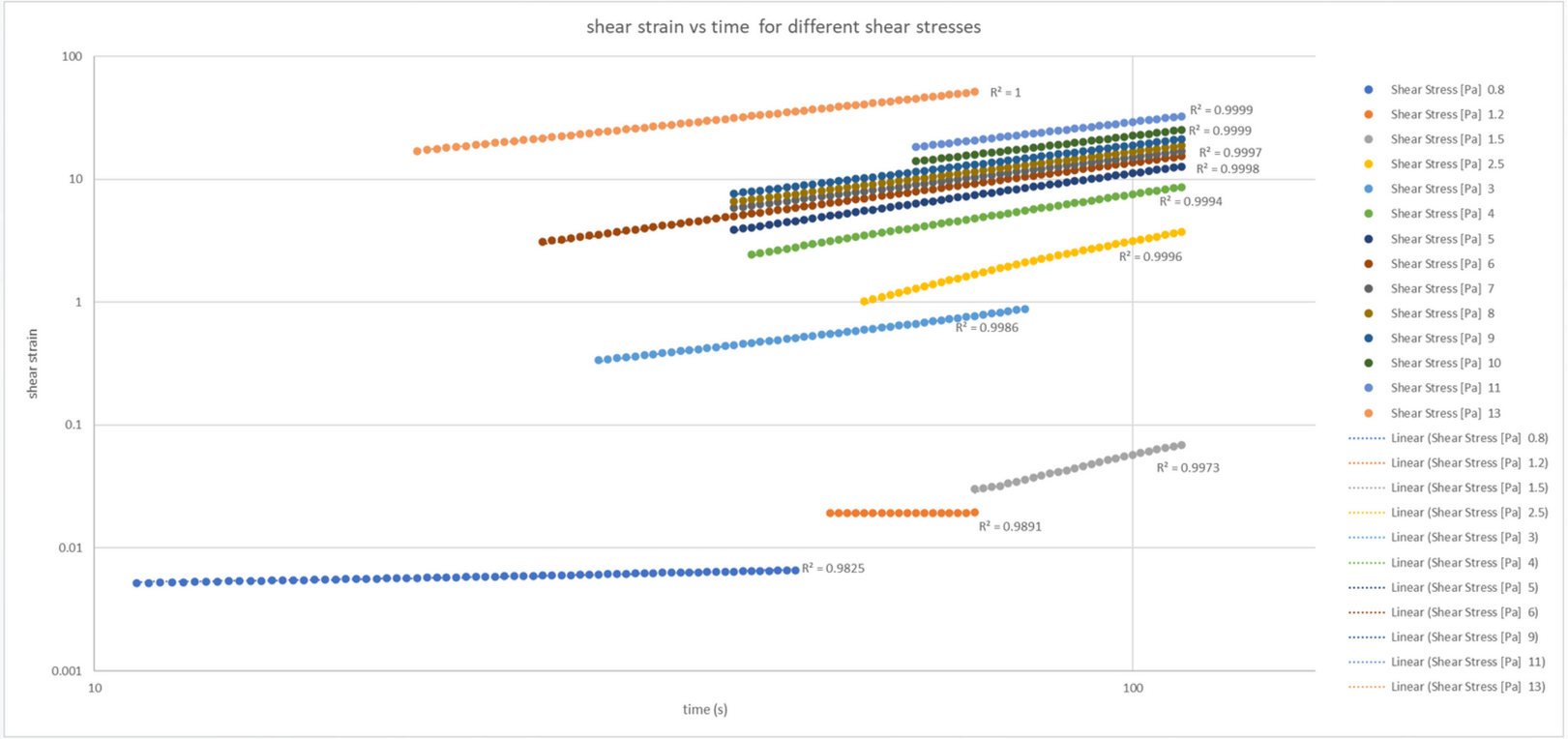
Collect and plot the data of strain vs time for different shear stress values



Results

Linear Regime

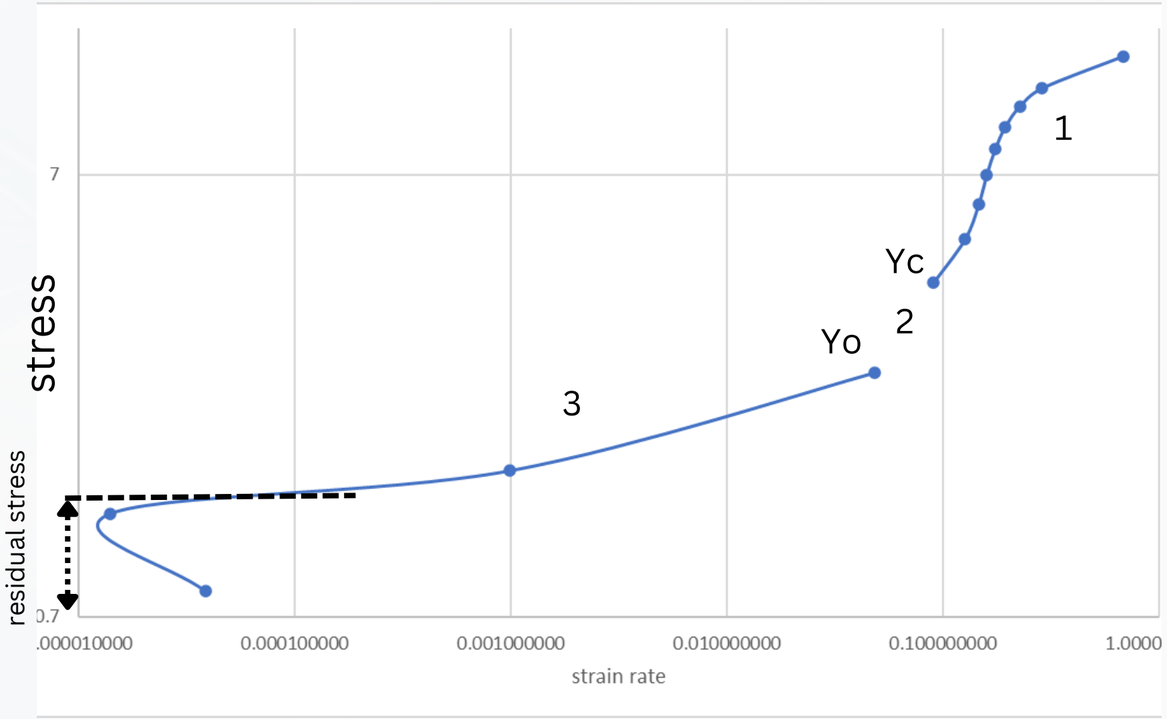
Find the linear regime and find the slope to get the data of strain rate against different stress values



Results

Stress vs Strain rate

stress	strain rate
0.8	0.000038568
1.2	0.000013972
1.5	0.000985427
2.5	0.048494623
3	0.011126143
4	0.090524416
5	0.126201018



stress	strain rate
6	0.146174190
7	0.159269247
8	0.174137617
9	0.194079841
10	0.226395276
11	0.287948023
13	0.686088814

Slip Thickness

a. Step 1

plot (Shear stress - residual stress) vs shear rate and get the slope of it

b. Step 2

Slip thickness = (viscosity of sillicon oil * gap between the plates) / (slope from step 1)