BRASS

1st International Seminar

on Design and Operation of Long-Distance Transportation Pipeline Systems

26th & 27th September 2024

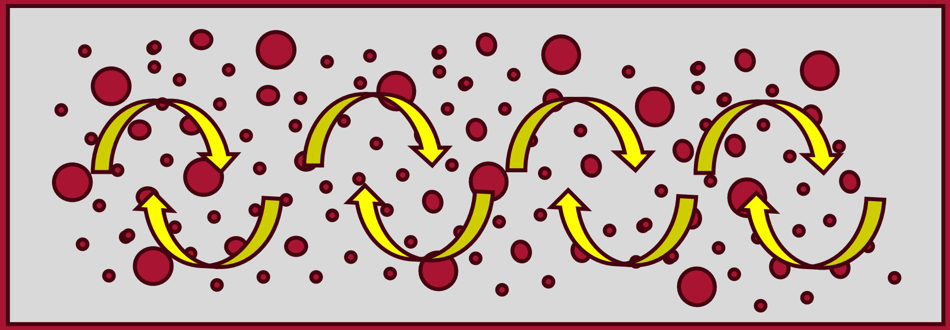
Slurry Properties In Pipeline Transport

Introduction

BRASS

The second most important parameter in the design of a long-distance slurry pipeline, after route selection, is the understanding of slurry transport properties.

Slurry is a mixture of a carrying fluid (process water) and solid particles (iron concentrate). This two-phase mixture can either be transported in homogeneous or heterogenous flow.



Slurry Properties

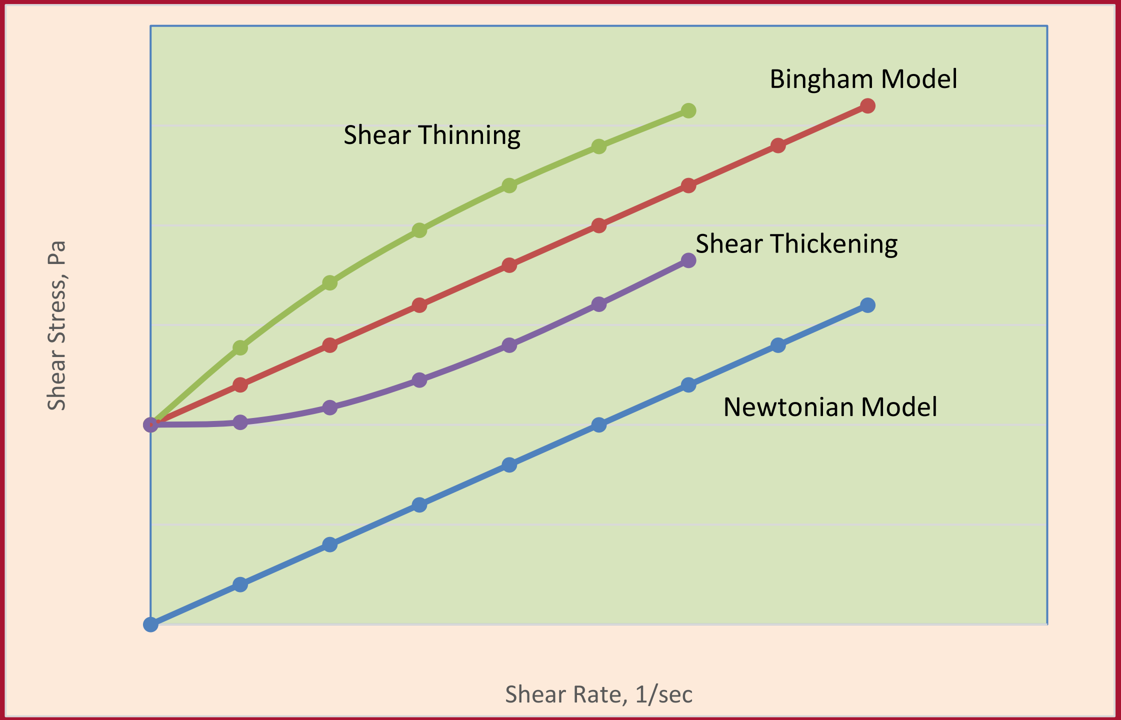
Particular attention should be given to the analysis of the following:

1. Slurry rheology
2. Particle Size Distribution
3. Slurry pH
4. Concentration of solids

Rheology

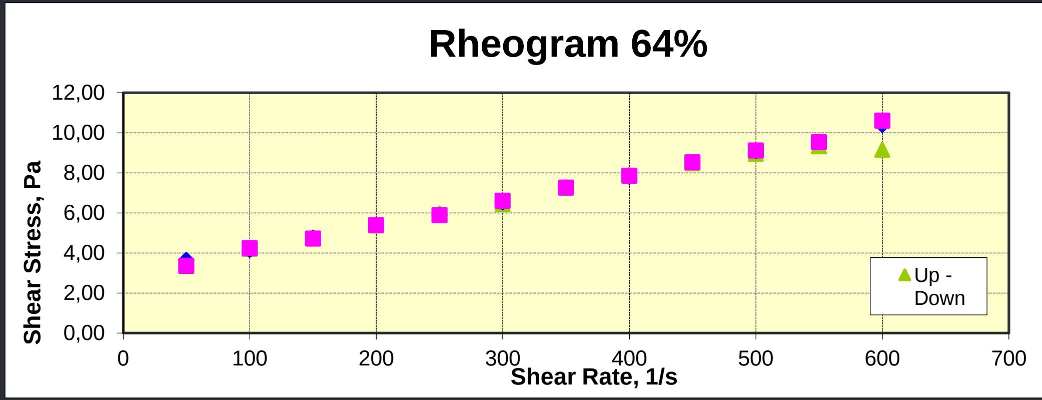
The slurry rheology helps the pipeline designer to determine the most efficient way in transporting the material.

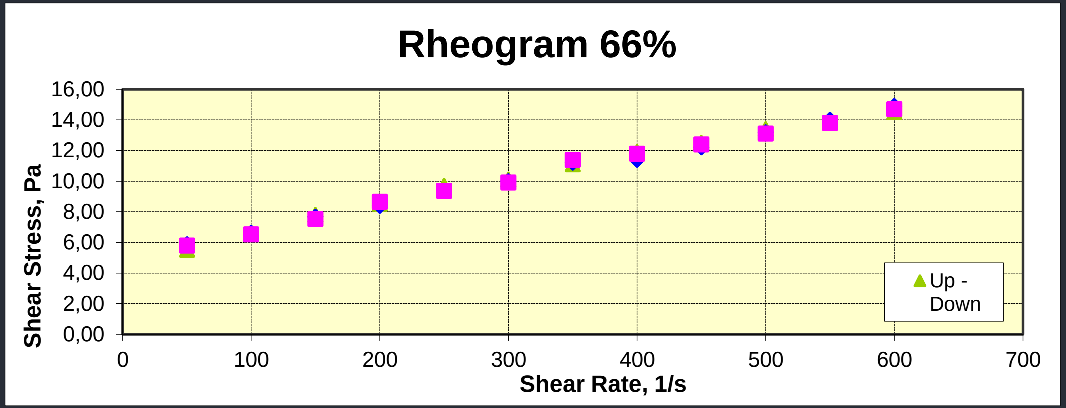
Slurries are characterized as Bingham and Non-Newtonian fluids.

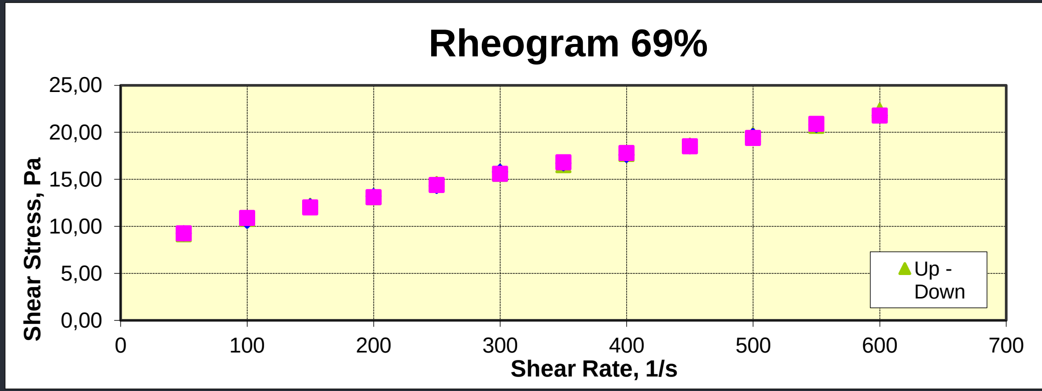


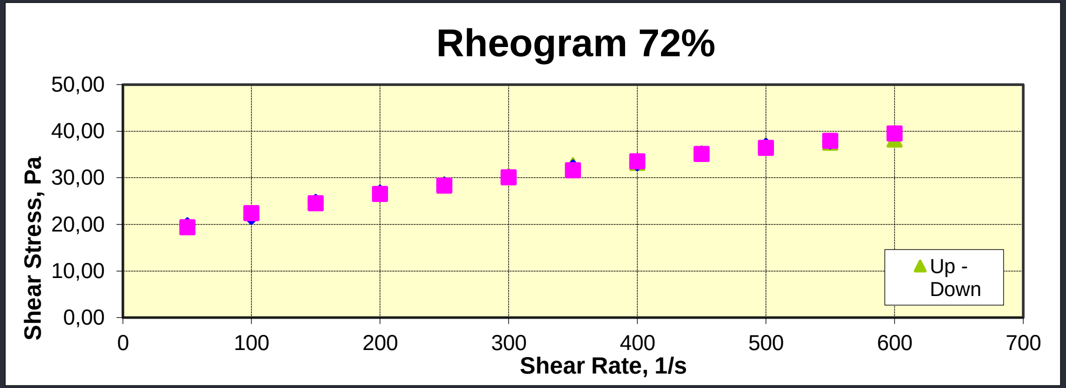
Rheology

- Non-Newtonian fluids poses variable viscosity and yield stress depending upon its particle size distribution and solid's concentration.









- Non-Newtonian fluids characteristic can be classified as time-independent (pseudoplastic, plastic and dilatant) and time-dependent (thixotropic and rheopectic)

- The property that interest the slurry pipeline designer is whether the slurry is thixotropic or rheopectic.

- A thixotropic slurry exhibits shear-thinning behavior when subjected to continuous shear over time. This property is advantageous for transporting the slurry using centrifugal pumps.

- A rheopectic slurry exhibits shear-thickening behavior when subjected to continuous shear over time. This property makes it more suitable for pumping with positive displacement pumps.

- If not properly identified, this property can lead to pressure increases in the pipeline during extended operations.

- How sensitive is the pipeline to variations in viscosity?

- Viscosity plays a crucial role in determining the most efficient method for transporting slurry. Changes in viscosity can directly impact the pumping power required and the overall flow behavior within the pipeline. Slurry viscosity can be influenced by the following parameters:

  - Pipeline Roughness Change
  - pH of Mixture
  - Temperature of Mixture
  - Cw Range

Rheology

BRASS

Consider the case of a change in Pipeline Roughness with the following :

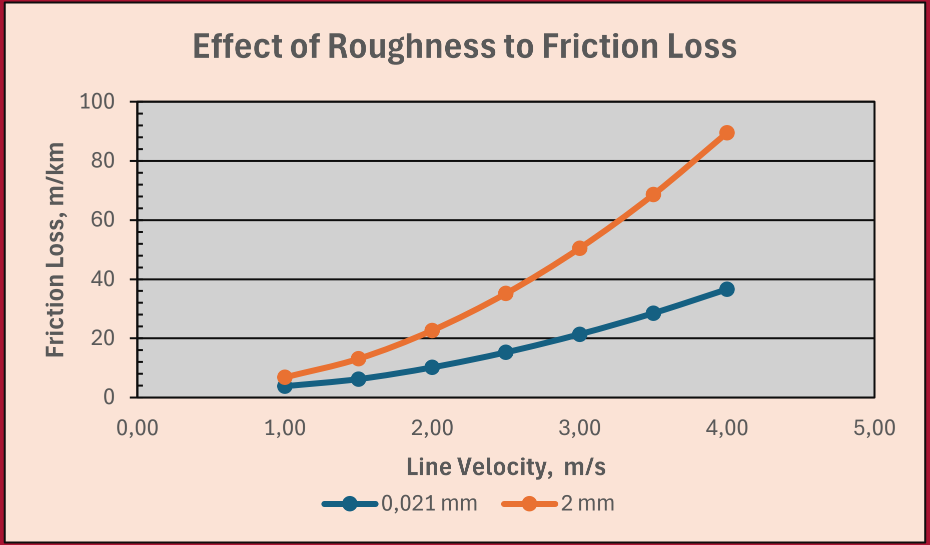
Fixed parameters:

- ❖Solids Concentration of 60%
- ❖Particle Size Consist, 65% passing 325 mesh
- ❖Viscosity of 3.95 cP
- ❖Yield Stress of 9.8 dynes/cm^2

Variable parameter:

- ❖ Initial Roughness, 0.021 mm
- ❖ Increased Roughness, 2.00 mm

Effect of Roughness to Friction Loss			
Line Vel.	0,021 mm	2 mm	%delta
V, m/s	J, m/km	J, m/km	
0.50	10.30	9.78	5%
1.00	3.82	6.82	79%
1.50	6.23	13.09	110%
2.00	10.20	22.67	122%
2.50	15.28	35.16	130%
3.00	21.39	50.47	136%



Rheology

Consider the case of a change in slurry pH with the following :

Fixed parameters:

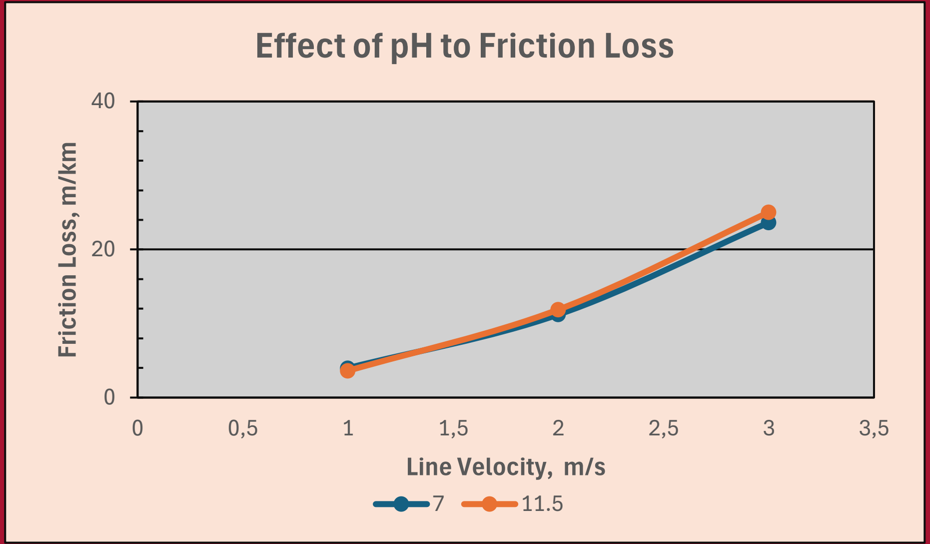
- ❖Solids Concentration of 65%
- ❖Particle Size Consist, 65% passing 325 mesh

Variable parameter:

- ❖ pH of 7.0, Viscosity of 8.62 cP
- ❖ pH of 11.5, Viscosity of 11.73 cP

Effect of pH Change to Friction Loss

Line Vel.	pH		% delta
V, m/s	7	11.5	
1	3.98	3.62	9%
2	11.22	11.89	6%
3	23.64	25.03	6%



Rheology

BRASS

Consider the case of a change in Slurry Temperature with the following :

Fixed parameters:

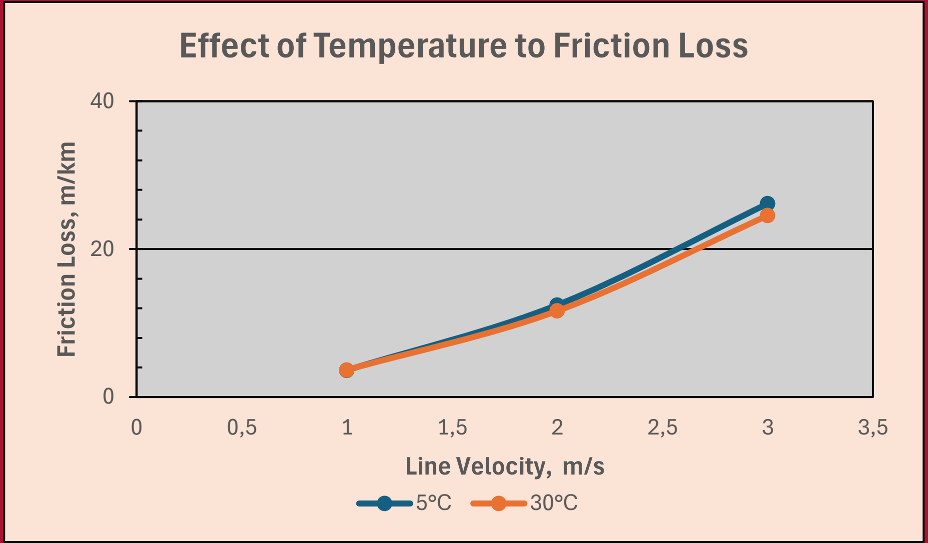
- ❖Solids Concentration of 65%
- ❖Particle Size Consist, 65% passing 325 mesh

Variable parameter:

- ❖ Temp of 5°C, Viscosity of 15.06 cP
- ❖ Temp of 30°C, Viscosity of 10.07 cP

Effect of Temperature Change to Friction Loss

Line Vel.	Temperature, °C		% delta
V, m/s	5	30	
1	3.63	3.67	1%
2	12.45	11.65	6%
3	26.15	24.55	6%



Conclusion

1. Slurry rheology (including viscosity and yield stress) is influenced by both particle size distribution and the solid concentration of the mixture. Any changes to these parameters will alter the slurry's rheology. Since these variables can fluctuate, it is essential to conduct thorough laboratory testing to fully understand the slurry’s rheological properties and flow behavior.

Conclusion

BRASS

2. The different cases evaluated revealed that changes in pipeline roughness have the most significant adverse effect on pipeline friction loss. Therefore, pipeline designers should anticipate a reduction in capacity due to increased roughness and recommend an appropriate cleaning frequency.

3. The cases evaluated indicated that changes in pH and temperature have a negligible effect on friction losses.

THANK YOU FOR YOUR ATTENTION