



## **Foundry 4.0 – Shell Room Experience with SlurryTrack Inline Viscosity Monitoring and Control System**

**Dr. Sunil Kumar, Dr. Joe Goodbread  
Rheonics GmbH, Winterthur, Switzerland**

# Importance of viscosity and density control in shell room operations



- **Why are slurry viscosity and density important in shell building?**
- **An evaluation of traditional methods for controlling slurry viscosity and density**
- **Factors affecting a viscosity/density measuring device selection for slurry application**

# Viscosity and density: Importance in shell building



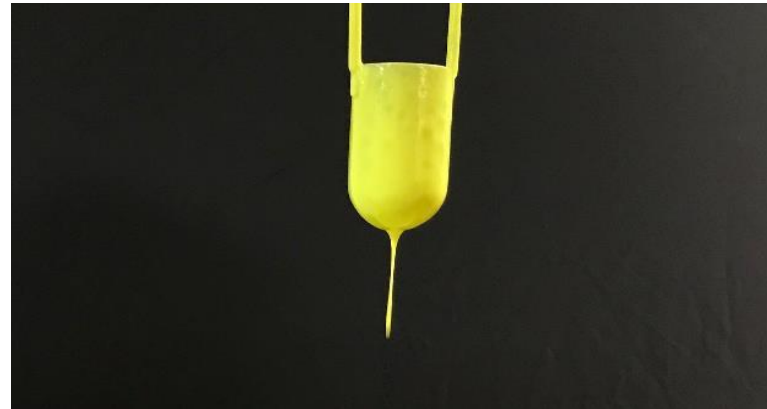
**Shell properties affected by viscosity and density of the slurry:**

- ◆ **Layer & final thickness**
- ◆ **Surface finish**
- ◆ **Permeability**
- ◆ **Strength**
- ◆ **Edge coverage**
- ◆ **Edge strength**
- ◆ **Bending strength**
- ◆ **Thermal characteristics**

# Requirements for a viscosity/density monitoring device from the casters' perspective



## Traditional methods: the Zahn cup



# Limits to Zahn cup accuracy and precision



**The Zahn cup is a simple and inexpensive method for checking the slurry consistency. Its precision and accuracy are limited by a number of subjective judgements the operator must make while making a measurement. Some factors limiting its precision are:**

## **Operator's subjective judgement**

- What criterion is used for end of measurement?
- How good are the operators attention and reaction time?

## **Condition of cup**

- How clean is it?
- How worn is it from abrasive slurry?

## **Temperature control**

- How accurate is temperature measurement?
- Is it identical to the drum temperature?

# Importance of Zahn cup measurements



- **Operator's familiarity and comfort with the method**
- **Correlates well with operator's subjective impression of slurry performance**
- **As a *de facto* standard, is necessary for quality control measurements to verify  
condition of slurry**

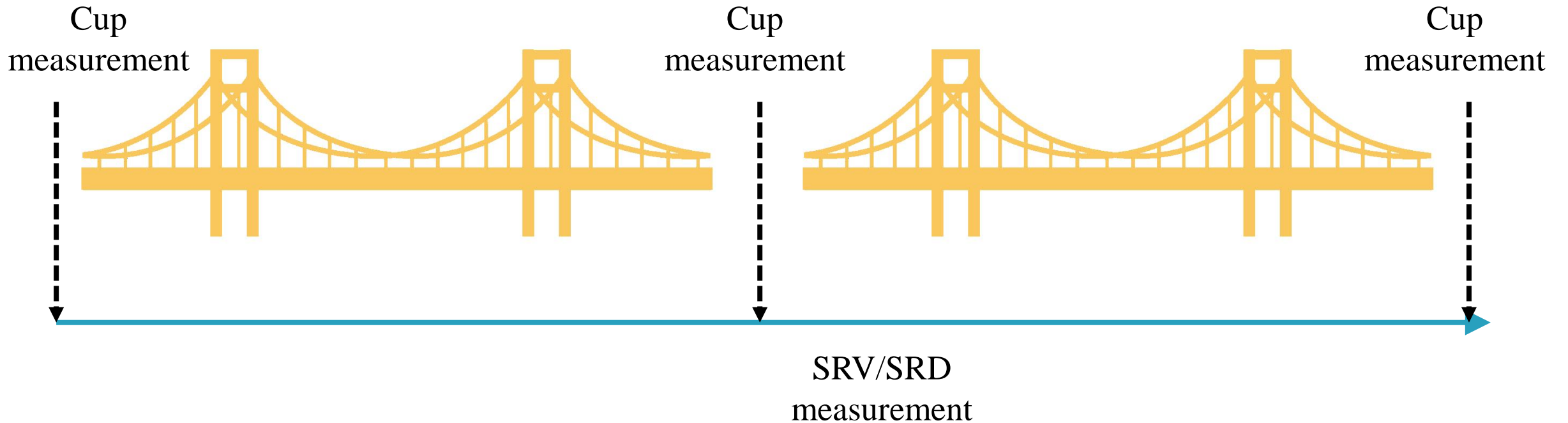
# SRV/SRD bridge slurry monitoring between cup measurements



**Although Zahn cup and SRV/SRD readings are fundamentally different, they each have an important function:**

- **Zahn cup compares slurry with specified values for quality control purposes**
- **SRV/SRD monitors viscosity and/or density in the tank, in real time, for monitoring and control purposes.**
- **Correlations are not necessary, but can be used for cross-checking inline with cup measurements**

# Quality control and quality maintenance



SRV/SRD build a bridge between successive cup measurements



# The resistance to adopting new measurement methods



1 km = 0.625 miles

1 mile = 1.60 km

My car gets 20 miles/gallon

My car uses 6 liters / 100 km

I have a fever if the thermometer reads over 98.6 ° F

I have a fever if the thermometer reads over 37 ° C

# Building correlations between Zahn cup and SRV/SRD



**The SlurryTrack and the Zahn cup can be friends, not competitors**

**Zahn cup:**

- **take quality control samples at intervals to check slurry consistency**

**SlurryTrack:**

- **Make continuous measurements to track changes in consistency**
- **Correlate with Zahn cup measurements**
- **Develop formulas to build confidence in SlurryTrack measurements**
- **Build database of correlations for different slurry compositions**

An ideal viscosity and density measuring system should be:



- **Repeatable**
- **Sensitive and Precise**
- **Robust**
- **Capable of continuous measurements**
- **Permanently calibrated**
- **Easy to interface with factory and enterprise data systems**
- **Transparent to the operator**

# Rheonics systems design and implementation: the sensor



**SRD density/viscosity sensor  
with electronics and display**

# Rheonics systems design and implementation: the analysis and control unit



Standalone SlurryTrack System

# Giving viscosity and density monitoring a place in the shell room: strategies for integration



- **Setting up a slurry monitoring system**
- **Strategies for monitoring slurry consistency**
- **Implementing automatic control of slurry consistency**
- **Cleaning and maintenance of sensors in an abrasive and adhesive world**
- **Possibilities of process optimization**
- **Future music – the role of cooperation and mutual learning**



## The hardware store: making room for the viscosity/density sensor in the slurry tank

- **Planning phase:**
  - **Do you need viscosity and density measurements, or is viscosity sufficient?**
  - **Will you be monitoring more than one drum in the same shell room?**
- **Where will you install it on the drum?**
- **Where will you locate the monitoring and control cabinet?**
- **How will you connect the system to your enterprise data network?**

# Knowing your requirements



Viscosity  
SRV



Density and Viscosity  
SRD





# One sensor or many



**How many slurry drums are in your shell room?**

**How many will be instrumented?**

# Setting up the sensor in the slurry drum



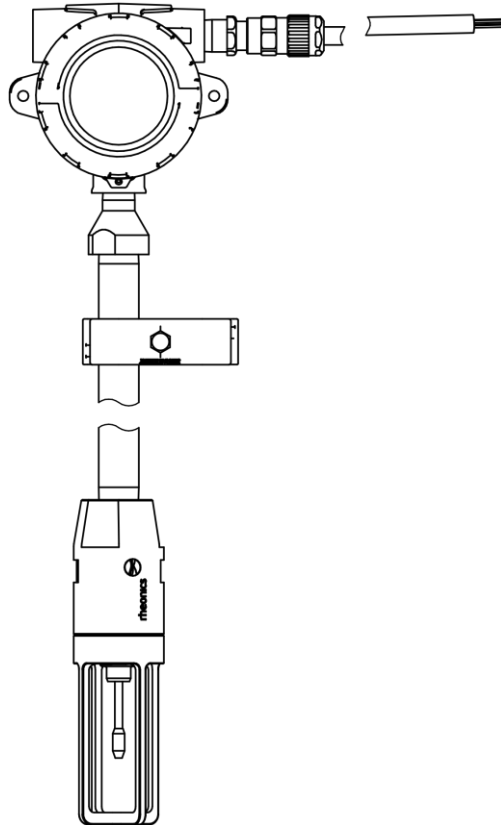
**SRV and SRD may be sensitive to the speed of slurry flowing over them. Therefore, it is necessary to have a system for repeatably placing the sensor in the same position in the drum each time it is removed for cleaning.**



Slurry properties may vary with depth. Repeatable measurements are ensured with the tank mount adapter



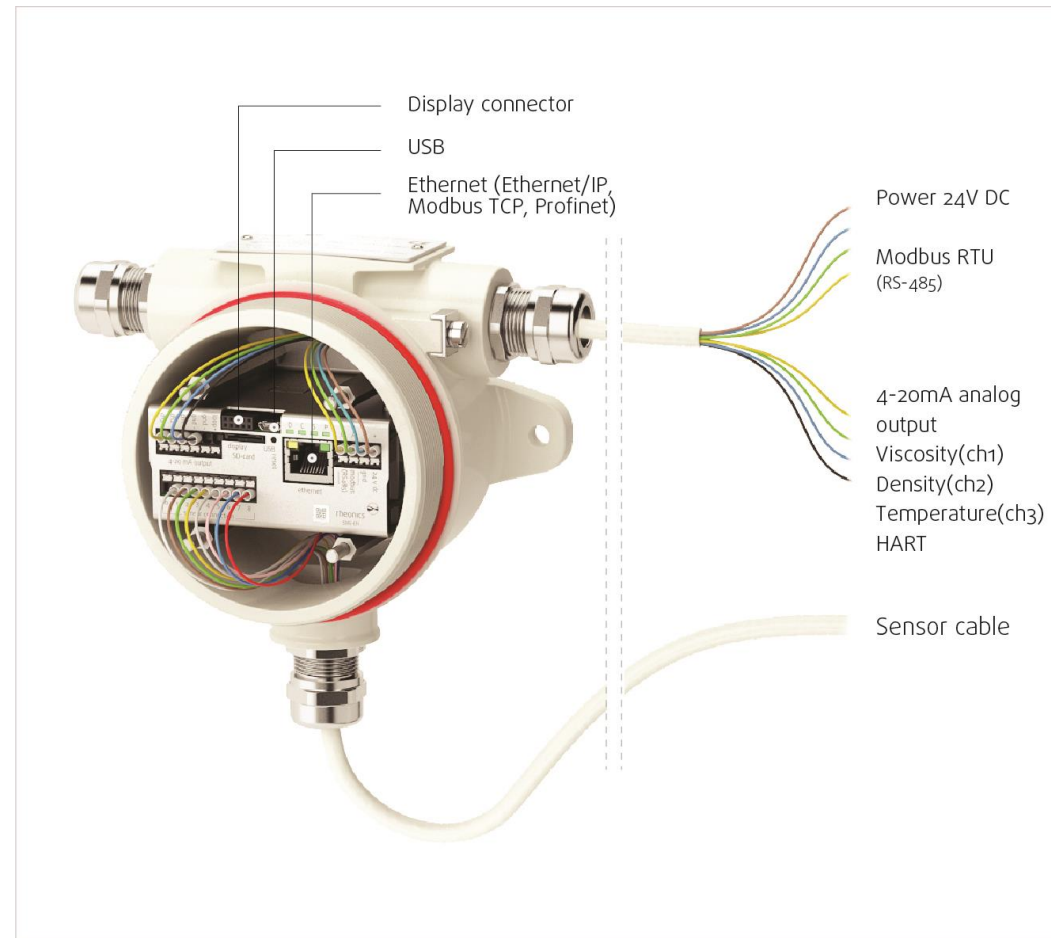
- Tank mount adapter ensures repeatable positioning
- Quick-release system allows easy re-positioning after cleaning



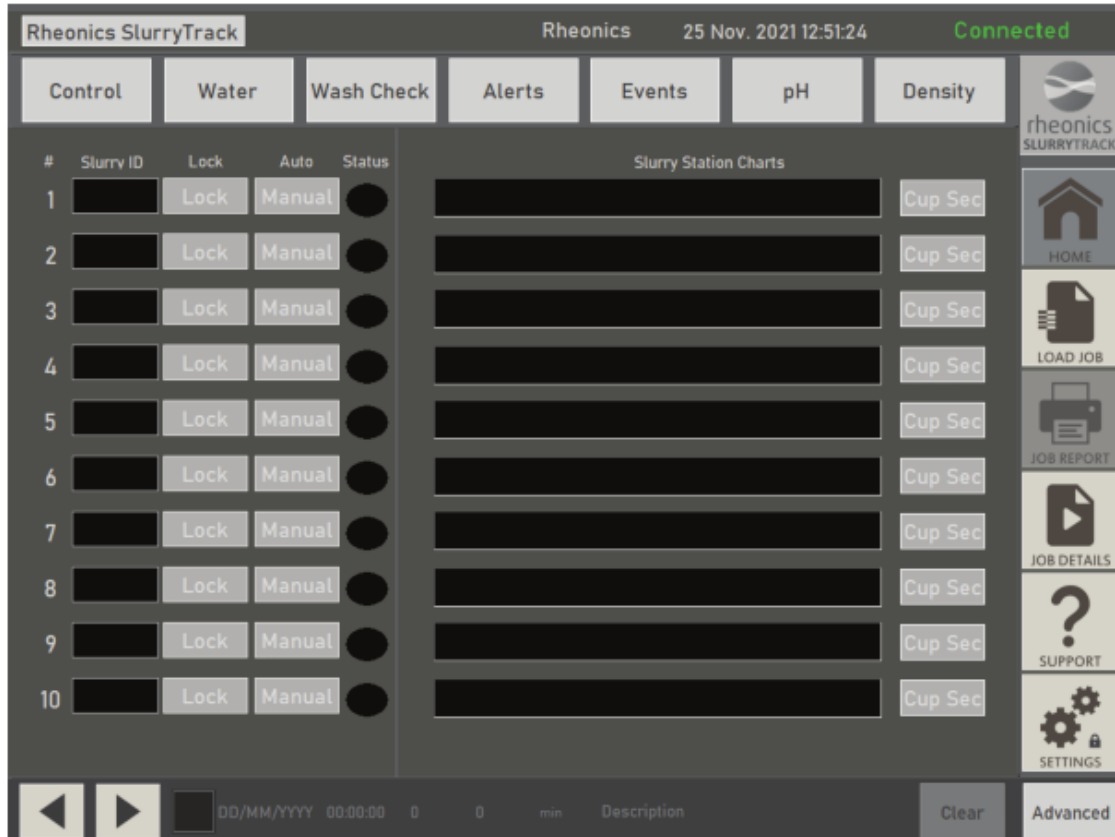
# Slurry monitoring: Connect and go!



The SRV and SRD come with a wide variety of data interfaces, ready to connect to either the SlurryTrack cabinet or directly to a PLC, PC or other in-house data system



# What to expect from the monitoring software

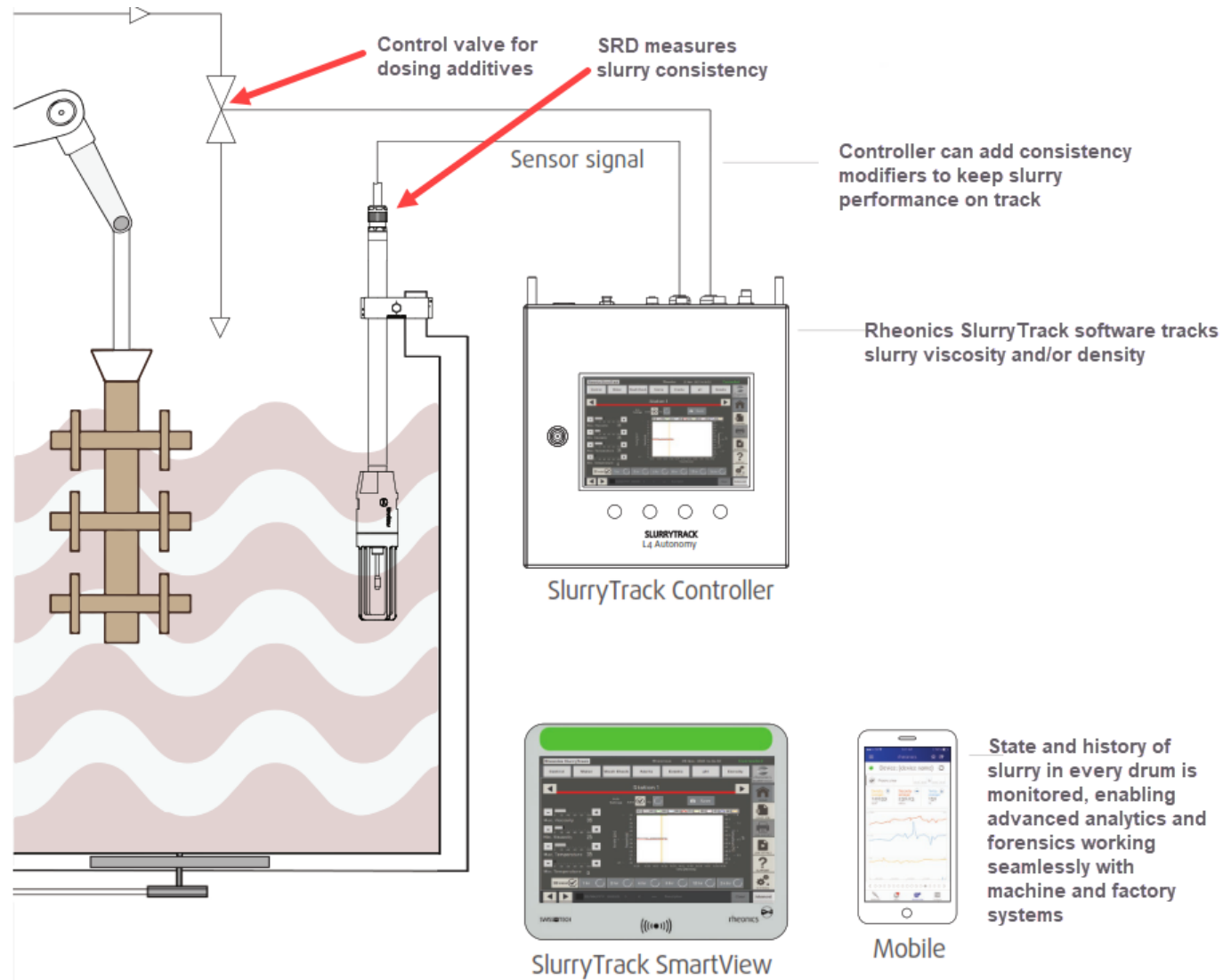


**Enter slurry type for each station**



**Start monitoring  
Press "Lock" to start control**

# Controlling slurry consistency



# Clean sensors in a challenging environment



- **Slurry is built to be sticky**
- **Slurry deposits on the sensor distort measurements**

**THEREFORE**

**KEEP IT CLEAN AND IT WILL GIVE RELIABLE DATA!**



**Built-in sensor check function detects deposits on SRV  
and notifies operator “time to clean me!”**



# Difficulty of detection of deposition on SRD



**Prevention is better than cure: periodic cleaning of the probe *before* it distorts readings is the best strategy**

- **Use tank mount adapter with quick-release mounting. Makes it easy to quickly remove, rinse, and replace the sensor in exactly the same position**
- **Mount sensor on a robotic arm that removes, rinses and re-inserts after each shell**

# Process optimization: benefits of enterprise data collection



- **Allows correlation of measured slurry consistency with yield and quality of finished castings**
- **High-resolution, repeatable measurements allow deeper understanding of slurry behavior**
- **High quality slurry data paves the way to automatic slurry consistency control**
- **Big data on slurry consistency and performance enables creative approaches to slurry formulation and management**



**Knowledge is power!**

**Sharing experience and knowledge strengthens the entire industry.**



- **Thanks to everyone who helped us make Rheonics sensors more useful for solving real-world shellroom challenges!**

# Acknowledgment



We would like to thank users of the SlurryTrack for very useful feedback on their experience with the sensors and system. Particular thanks to Mark Christensen from PCC Structural for feedback on this presentation, and for helping us understand some of the basic issues affecting performance of these systems from an operator's perspective.