



*Setting the Standard for Automation™*

# PAPER 18 - USING VISCOMETERS TO CONTROL BATCH POLYMERIZATION REACTIONS

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Standards  
Certification  
Education & Training  
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# Summary

- VISCOSITY A KEY PARAMETER
- HOW TO MEASURE VISCOSITY?
- PROCESS VISCOSITY MEASUREMENT
- VIBRATION AT RESONANCE FREQUENCY
- VISCOSITY TO MONITOR POLYMERIZATION
- EXAMPLE OF APPLICATION USING A RESONANCE VIBRATION VISCOMETER
- NEW TECHNOLOGICAL IMPROVEMENTS
- CONCLUSION

# VISCOSITY A KEY PARAMETER

- One of the most commonly measured physical property
  - Quality specification for many products
  - Correlated to other key features of products such as molecular weight of polymers or solids content in a slurry
  - Necessary for the optimization of most liquid processes

# HOW TO MEASURE VISCOSITY?

- **LABORATORY TECHNOLOGIES:** traditionally used with reliable measurements of viscosity but
  - Do not allow a real time and continuous measurement
  - Can cause measurement errors if there are changes between the sampling and viscosity measurement
  - Operator dependent
  - Are expensive



## PROCESS VISCOSITY MEASUREMENT

# PROCESS VISCOSITY MEASUREMENT

- LABORATORY ADAPTED TECHNOLOGIES:

- Rotational
- Capillary viscometer
- Falling ball
- Moving Piston

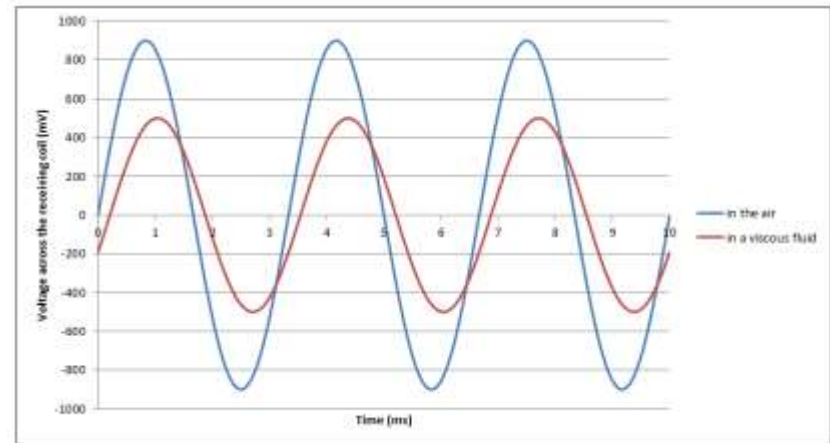
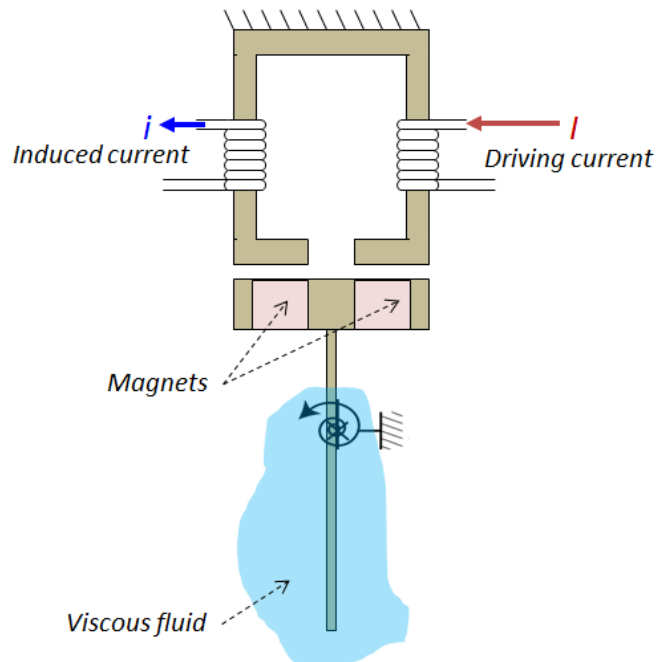
Not reliable enough due to drifts concerns  
from wear and/or fouling



VIBRATION AT RESONANCE FREQUENCY

# VIBRATION AT RESONANCE FREQUENCY

- In 1981, SOFRASER patented the first viscometer using vibrating technology at resonance frequency
- Principe :



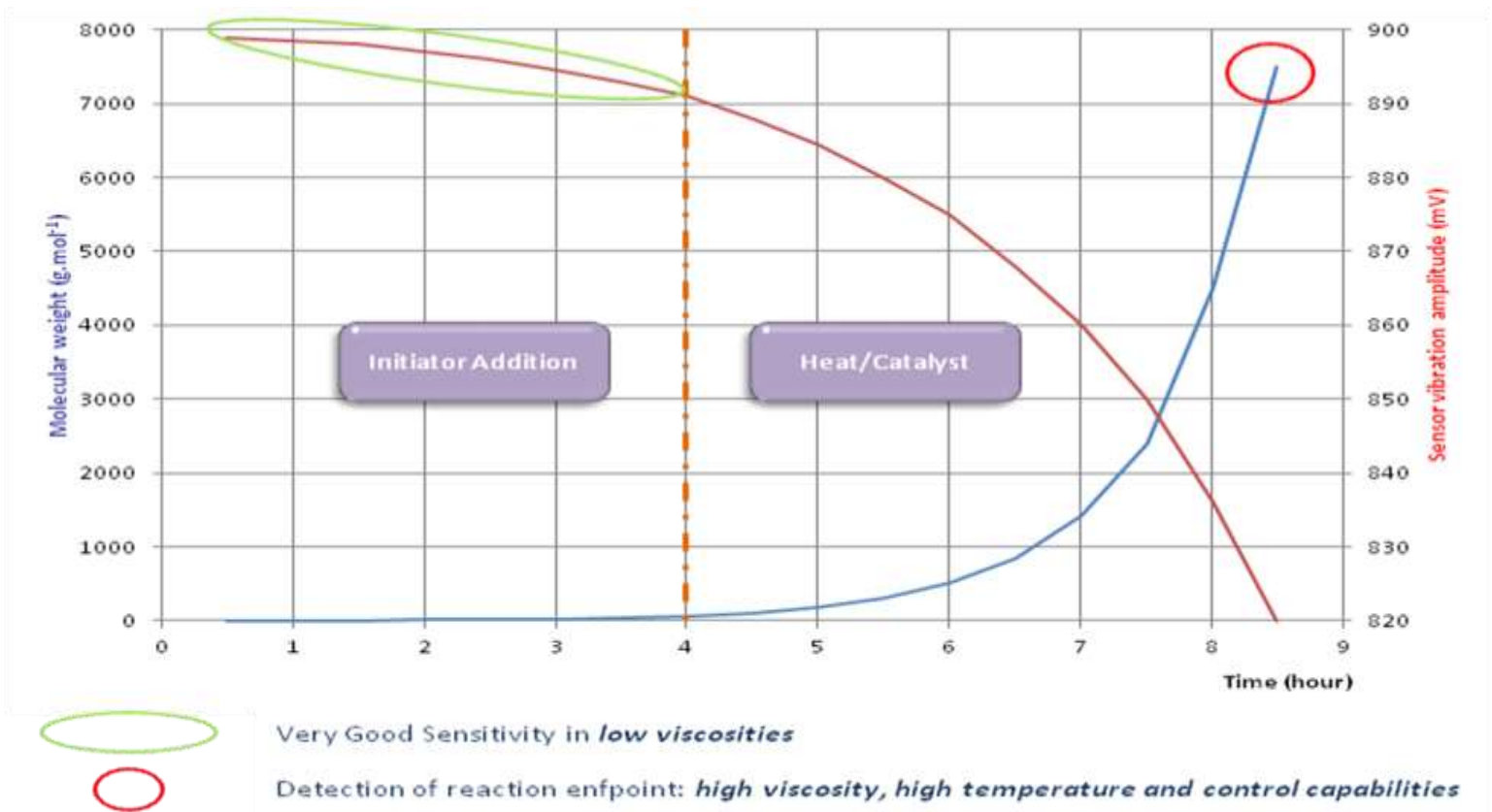
# VIBRATION AT RESONANCE FREQUENCY

- Vibrating viscometer at resonance frequency operating at a high shear rate:
  - Measures viscosity continuously and instantaneously
  - Reduce measurement fluctuations due to flow rate when the product is pseudo-plastic
  - Is adapted to process measurement and unaffected by external vibration
  - Can be used in high viscosity, high pressure, high temperature, hazardous areas and aggressive chemicals



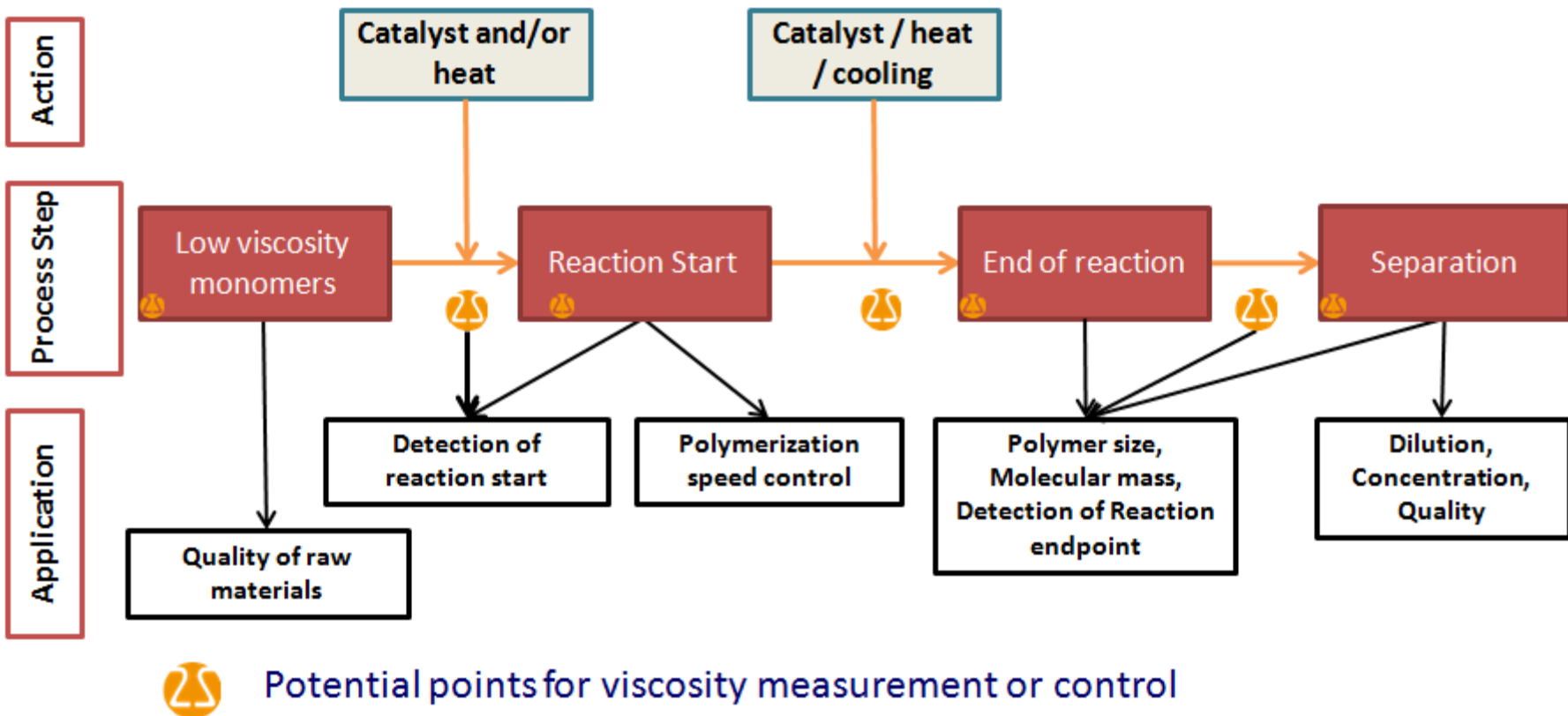
# VISCOSITY TO MONITOR POLYMERISATION

- Perfectly adapted to polymerization control:  
One single sensor to monitor the entire reaction.



# VISCOSITY TO MONITOR POLYMERISATION

- In each step of production



# VISCOSITY TO MONITOR POLYMERISATION

- Viscosity is function of **polymerization reaction**
  - Reaction is **too fast** and/or exothermic:
    - bad polymer quality (heterogeneity)
    - impossibility to stop the reaction (dangerous hardening)
  - Reaction is **too slow**:
    - low productivity (time loss, energy consumption)
    - unavailability of final product (will never become hard or soft as expected)
- Viscosity is a **physical property of the end product**
  - **Product ready to be used** (moulded, laminated, extruded, etc.)
  - **Product can be stocked** (resins, glues, formaldehyde, acrylic resins, polystyrenes, polyurethane viscose, polyisobutylene, methylmetacrylates, etc.)

## AN EXAMPLE OF APPLYING VISCOMETER USING VIBRATION AT RESONANCE

- Phenol-formaldehyde resin
- Closely monitored to manage the exothermic reaction and avoid reaching point of no-return (resin hardens and batch/equipment is lost)
- Conditions :
  - Process Temperature: 440°F
  - Process Pressure: 13 psig
  - Class 1 Div 2 Area
  - Viscosity change: From 1,000 cP to 30,000 cP
  - Batch Duration: 4-5 hours in 10,000 gal reactor



# EXAMPLE OF APPLICATION USING A RESONANCE VIBRATION VISCOMETER

- Results:



- Results

- Time benefits: Reduction of batch time by 30 minutes (average)
- Monetary benefits:
  - 2 more batches per week
  - No more hardening of the resin

# CONCLUSION

- Vibrating viscometers at resonance frequency are the optimal solution to :
  - Measure viscosity in process conditions
  - Monitor batch polymerization
  - Measure simultaneously density and viscosity of the fluid

# CONCLUSION

## Improvement of manufacturing capacity

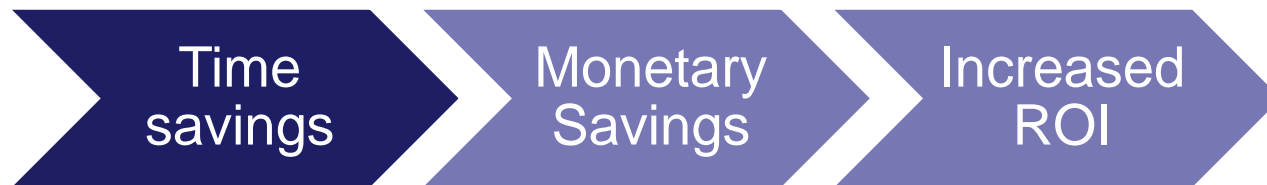
Optimization of process steps: start of polymerization, extent of reaction, end-point

## Better end-product quality

Accurate detection of reaction end-point

## Increased process security

Prevention of hardening: saves reactor cleaning time and rejected batch





Thank you for your attention

Question?