Development and Implementation of an Automatic Continuous Online Monitoring and Control Platform (ACOMP) for Polymerization Reactions to Sharply Boost Energy and Resource Efficiency in Polymer Manufacturing

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Why Polymers are Important











Why Polymers are Important

Our Vision

The $1T+ polymer industry has $Billions per year in process inefficiency, including waste of energy and non-renewable resources

This project targets eliminating this inefficiency and enhancing sustainability

Project Objective

- Goal: the project aims to develop completely automated feedback control of polymer manufacturing, utilizing data from advanced online analyzer technology developed and patented at Tulane, coupled to predictive models in development- all validation will occur at the pilot scale

- Problem: most polymer processes, batch, semi-batch and continuous require off-line analytics to validate, quality control and even control production. Even many control models require regular off-line analytic inputs for 'corrections'

- Sampling, measurement and characterization of polymers is a complex process, even offline

- Simplification, automation and extensive data modeling and analytics are required to make automated polymer manufacturing a success

Technical Approach

How it's Done Now

Reactor

QC Lab

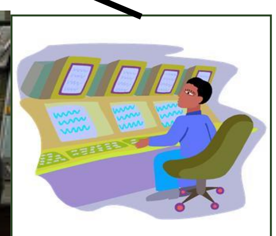
$Ms in annual waste & inefficiency per reactor

Failed R. Control

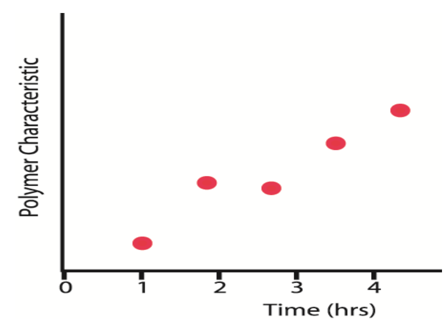
Plant Control System

Oper. Control

Reaction Data

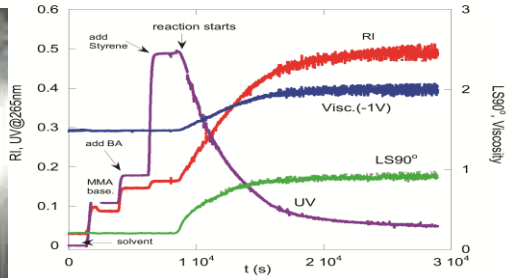


Plant Control Room



What ACOMP can Enable Today

Reactor



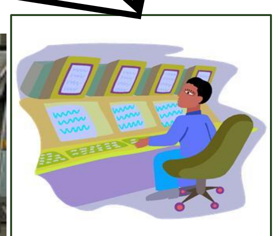
ACOMP

Reaction Control

R. Data

Oper. Control

Plant DCS



Plant Control Room

QC Lab

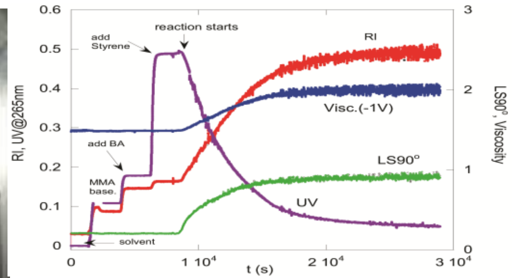
Benefit to Plant User

- Cost-savings
- Yield increase
- Improved product quality
- Energy efficiency

Technical Approach

How ACOMP/CI Will Work

Reactor



ACOMP

QC Lab

Reaction Control

R. Data

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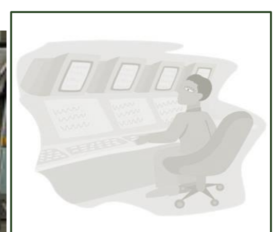
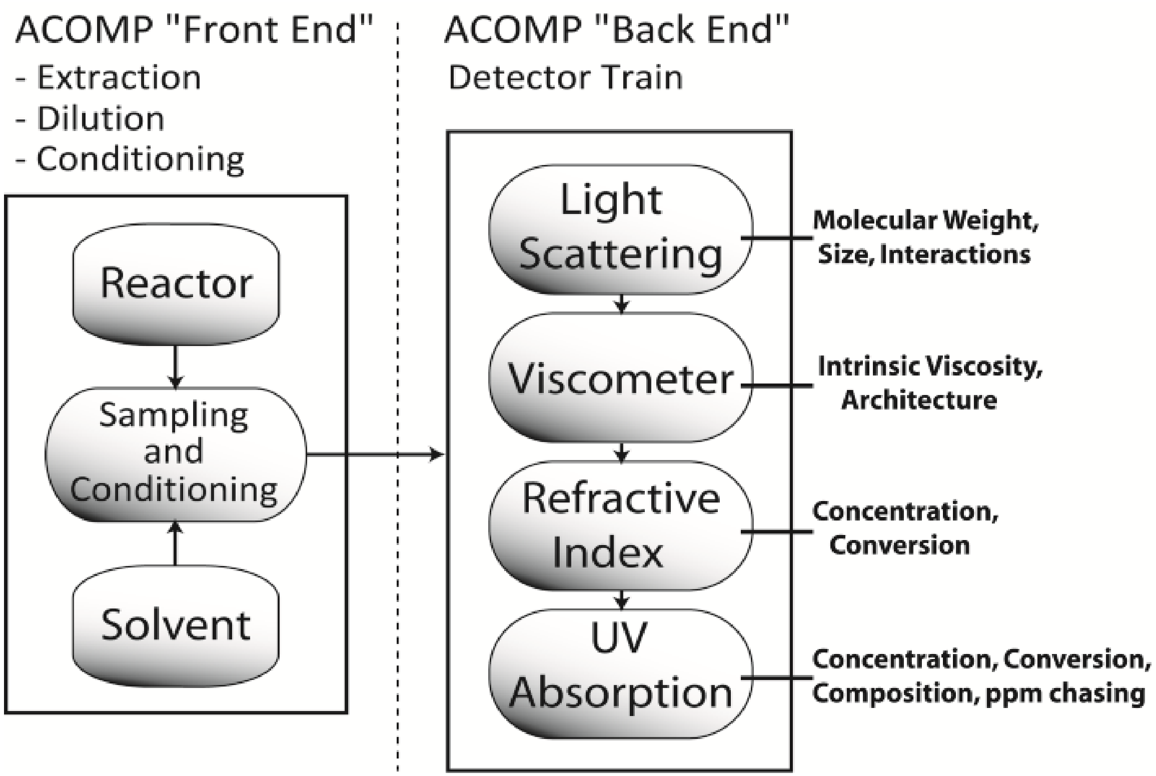


Automated Feedback Control- This Project

Plant Control Room

Technical Approach

- We are relying on sampling/conditioning technology that withdraws sample and measures it continuously, yielding data on multiple critical polymer properties



Technical Approach

- We are relying on sampling/conditioning technology that withdraws sample and measures it continuously, yielding data on multiple critical polymer properties
- We've demonstrated monitoring works at lab, pilot and industrial scale so predictive models driven by this data are logical next step
- Multidisciplinary team comprised of scientists, engineers and businesspeople from universities, a high tech startup, manufacturers and other technology partners, including automation and instrument firms
- Start-up team and advisors have extensive experience in commercialization of technology

Transition and Deployment- Why it's Important

- Chemical industry supports nearly 25% of U.S. GDP (supports other critical manufacturing sectors: auto, heavy equipment, aerospace, etc.)*
- Est. $250 B in U.S. shipments in 2013 (subset of $812 B US Chemical manufacturing industry)*
- Direct+indir. employment for entire chemical industry= 6M+*
- Average pay for all chemical industry workers: $88,800*
- The chemical industry is 2nd largest consumer of all U.S. manufacturing energy at 24.4%**
- Annual consumption 2,700 Trillion Btus equivalent to 470 million barrels of crude oil**
- Highest carbon emissions of any industry at 22.2% of all manufacturing emissions**

*From American Chemistry Council research
** From DoE-EIA energy consumption and industry emissions surveys

Transition and Deployment

- End-user: small, medium and large polymer manufacturers
  - Manufacturers will purchase and operate monitoring and control platform
  - The platform will improve efficiency, yield, profitability and product quality of polymer production processes
- Commercialization Approach
  - Start-up (APMT, Inc.) has exclusive license to IP from Tulane and has also filed multiple new patents
  - Partnerships with instrumentation and automation companies have been developed to prepare to scale
  - Validation of monitoring technology (**w/out predictive control**) at industrial scale - 17% reduction in cycle time
- Capital equipment & service model coupled w/SaaS sales model for any software modeling and data analytics features

Measure of Success

- With completely automated feedback control of polymerization reactions, the team expects:
  - Reduction of batch cycle time, grade changeover time, off-spec production, unexpected production events
  - Resulting in reduced energy and material feedstock consumption per lb. of polymer produced
  - Success will be measured based on comparison of production performance before and after adoption of the platform for specific KPIs e.g. yield, quality, energy consumption, material usage, off-spec, cycle time, changeover time, etc.
- Energy impact
  - Reduced electricity usage for heating/cooling, equipment utilization
  - More efficient use of petroleum-derived feedstock
- Economic impact- annual cost savings and added capacity valued at $Millions per reactor (1,000+ reactors in U.S.)

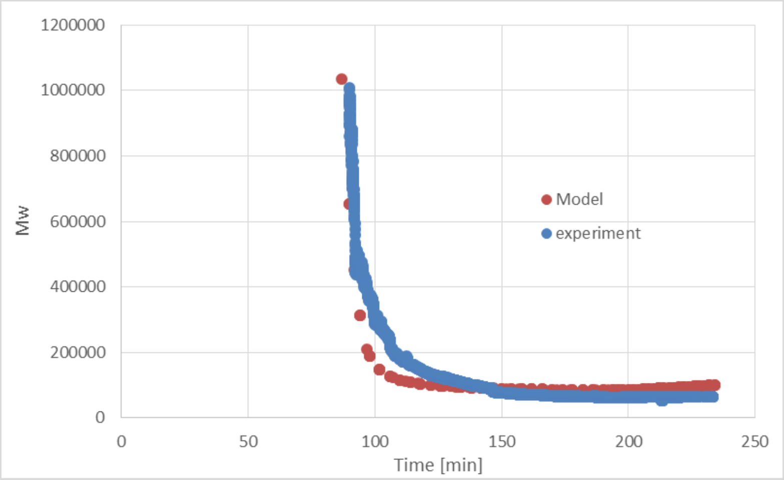
Project Management & Budget

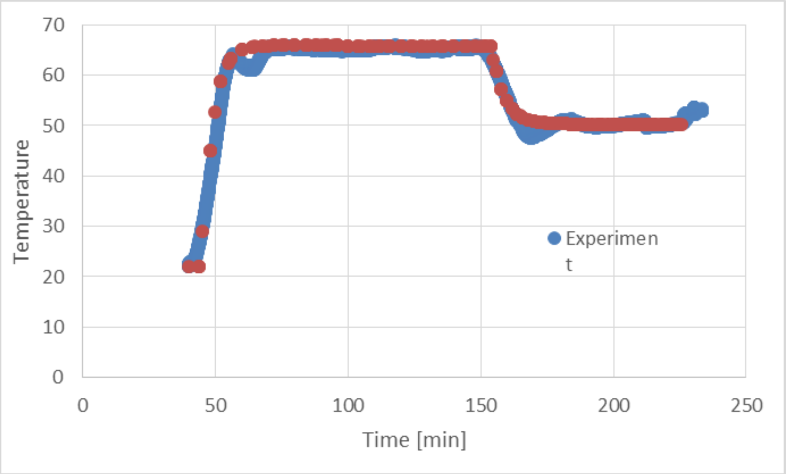
- 2 year project
- Milestone 1: Conceptual demonstration of control at lab scale utilizing existing equipment- **9/30/15**
- Milestone 2 (go/no-go): Full pilot scale demonstration utilizing newly assembled pilot system, monitoring system and active manual control of a batch polyacrylamide reaction- **12/31/15**
- Milestone 3: Industrially relevant reactions monitored and controlled at pilot scale- **11/30/16**
- Milestone 4: Advanced control algorithms incorporated into platform software for full automatic active control- **11/30/16**

Total Project Budget	
DOE Investment	$1,500,000
Cost Share	$376,452
Project Total	$1,876,452

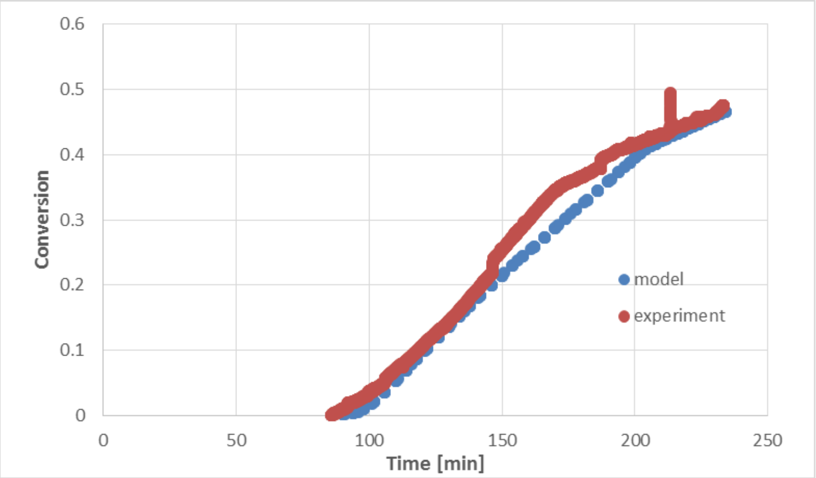
Results and Accomplishments

- Conceptual validation underway, pilot control and monitoring system builds ahead of schedule, software development initiated, 2 Provisional patent applications filed, and new sampling technology under development





The first comparison of the LSU gPROMS computational modeling and Tulane ACOMP experiment are shown for free radical polymerization of MMA in butyl acetate, initiated by AIBN. Early results are promising



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Photograph of pilot scale control and monitoring system builds

- Deploy pilot control system and monitoring platform
- Finalize control algorithms and test monitoring and control platform on ideal polymer system
- Test entire platform at pilot scale on industrially relevant polymer systems working with industrial collaborators