ANNOUNCEMENT

UNITED STATES DEPARTMENT OF ENERGY (DOE)
Scientific and Technical Information (STI) For Financial
Assistance Recipients and Non-M&O/M&I Contractors

PART I: STI PRODUCT DESCRIPTION
(To be completed by Recipient/Contractor)

A. STI Product Identifiers

1. REPORT/PRODUCT NUMBER(s)

DOE/GO10521

2. DOE AWARD/CONTRACT NUMBER(s)

DE-FG36-00GO10521

3. OTHER IDENTIFYING NUMBER(s)

None

B. Recipient/Contractor

George E. Dzyacky, Principal Investigator

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C. STI Product Title

Final Report, Distillation Column Flooding Predictor

D. Author(s)

H. Sponsoring DOE Program Office

Inventions & Innovation Program

I. Subject Categories (list primary one first)

02, 99

Keywords

Petroleum; Information Processing; Process Control;
Pattern Recognition; Distillation; Separation;

J. Description/Abstract

The Flooding Predictor is an advanced process control strategy comprising a patented pattern-recognition methodology that identifies pre-flood patterns discovered to precede flooding events in distillation columns. The grantee holds a U.S. patent on the modeling system. The technology was validated at the Separations Research Program, The University of Texas at Austin under a grant from the U. S. Department of Energy, Inventions & Innovation Program.

Distillation tower flooding occurs at abnormally high vapor and/or liquid rates. The loss in tray efficiencies is attributed to unusual behavior of liquid inventories inside the column leading to conditions of flooding of the space in between trays with liquid. Depending on the severity of the flood condition, consequences range from off spec products to equipment damage and tower shutdown.

This non-intrusive pattern recognition methodology, processes signal data obtained from existing column instrumentation. Once the pattern is identified empirically, it is modeled and coded into the plant's distributed control system. The control system is programmed to briefly "unload" the tower each time the pattern appears. The unloading takes the form of a momentary reduction in column severity, e.g., decrease bottom temperature, reflux or tower throughput.

Unloading the tower briefly at the pre-flood state causes long-term column operation to become significantly more stable - allowing an increase in throughput and/or product purity. The technology provides a wide range of value between optimization and flooding. When a distillation column is not running at capacity, it should be run in such a way ("pushed") that optimal product purity is achieved.

Additional benefits include low implementation and maintenance costs, and a high level of console operator acceptance. The previous commercial applications experienced 98% uptime over a four-year period. Further, the technology is unique in its ability to distinguish between different flooding mechanisms within the same tower, e.g., liquid and jet flooding.

K. Intellectual Property/Distribution Limitations

(must select at least one; if uncertain contact your

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E. STI Product Issue Date/Date of Publication

05/31/2003 _____ (mm/dd/yyyy)

F. STI Product Type *(Select only one)*

☒ 1. TECHNICAL REPORT
   ☒ *Final* ☐ *Other (specify)* _____

☐ 2. CONFERENCE PAPER/PROCEEDINGS
   Conference Information (title, location, dates)

   _____
   _____
   _____

☐ 3. JOURNAL ARTICLE

   a. *TYPE:* ☐ *Announcement Citation Only*
      ☐ *Preprint* ☐ *Postprint*
   b. *JOURNAL NAME*

   _____
   c. *VOLUME* _____ d. *ISSUE* _____
   e. *SERIAL IDENTIFIER (e.g. ISSN or CODEN)*

   _____

☐ OTHER, SPECIFY

   _____

G. STI Product Reporting Period *(mm/dd/yyyy)*

07/01/2000 _____ *Thru* 02/28/2003 _____

Contracting Officer (CO))

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☐ 2. COPYRIGHTED MATERIAL: *Are there any restrictions based on copyright?* ☐ *Yes* ☐ *No*
   If yes, list the restrictions as retained in your contract

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   INVENTION DISCLOSURE SUBMITTED TO DOE:
   DOE Docket Number: S- _____
   (Sections are marked as restricted distribution pursuant to 35 USC 205)

☐ 4. PROTECTED DATA: ☐ *CRADA* ☐ *Other*
   If other, specify _____
   Release date (mm/dd/yyyy) _____

☐ 5. SMALL BUSINESS INNOVATION RESEARCH (SBIR) DATA
   Release date (Required, _____
   (No more than 4 years from date listed in part 1.E above)

☐ 6. SMALL BUSINESS TRANSFER (STTR) DATA
   Release date (Required, _____
   No more than 4 years from date listed in part 1.E above)

☐ 7. OFFICE OF NUCLEAR ENERGY APPLIED TECHNOLOGY

L. Recipient/Contractor Point of Contact *Contact for additional information (contact or organization name to be included in published citations and who would receive any external questions about the content of the STI Product or the research contained therein)*

Name and/or Position

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Organization N/A

ANNOUNCEMENT

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Scientific and Technical Information (STI) For Financial
Assistance Recipients and Non-M&O/M&I Contractors

PART II: STI PRODUCT MEDIA/FORMAT and LOCATION/TRANSMISSION
(To be completed by Recipient/Contractor)

A. Media/Format Information:
1. MEDIUM OF STI PRODUCT IS:
   ☒ Electronic Document ☐ Computer medium
   ☐ Audiovisual material ☐ Paper ☐ No full-text
2. SIZE OF STI PRODUCT ___14 MB___
3. SPECIFY FILE FORMAT OF ELECTRONIC DOCUMENT BEING TRANSMITTED, INDICATE:
   ☐ SGML ☐ HTML ☐ XML ☒ PDF Normal ☐ PDF Image
   ☐ WP-Indicate Version *(5.0 or greater)* _____
   Platform/operating system _____
   ☒ MS-Indicate Version *(5.0 or greater)* ___Adobe 5.0___
   Platform/operating system ___Windows XP Pro___
   ☐ Postscript _____
4. IF COMPUTER MEDIUM OR AUDIOVISUAL
   a. Quantity/type *(specify)* ___1 Recordable Compact Disk___
   b. Machine compatibility *(specify)* ___IBM; PC compatible___
   c. Other information about product format a user needs to know: _____

B. Transmission Information:
STI PRODUCT IS BEING TRANSMITTED:
   ☐ 1. Electronic via Elink
   ☒ 2. Via mail or shipment to address indicated in award document *(Paper products, CD-ROM, diskettes, videocassettes, et.)*

   ☐ 2a. Information product file name
      (of transmitted electronic format)
   _____

PART III: STI PRODUCT REVIEW/RELEASE INFORMATION
(To be completed by DOE)

A. STI Product Reporting Requirement Review:
   ☐ 1. THIS DELIVERABLE COMPLETES ALL REQUIRED DELIVERABLES FOR THIS AWARD
   ☐ 2. THIS DELIVERABLE FULFILLS A TECHNICAL REPORTING REQUIREMENT, BUT SHOULD NOT BE DISSEMINATED BEYOND DOE.

B. DOE Releasing Official
   ☐ 1. I VERIFY THAT ALL NECESSARY REVIEWS HAVE BEEN COMPLETED AS DESCRIBED IN DOE G 241.1-1A, PART II, SECTION 3.0 AND THAT THE STI PRODUCT SHOULD BE RELEASED IN ACCORDANCE WITH THE INTELLECTUAL PROPERTY/DISTRIBUTION LIMITATION ABOVE.

Released by *(name)* _____

Date _____
   (mm/dd/yyyy)

E-mail _____

Phone _____

Final Technical Report

Title Page

May 31, 2003

Distillation Column Flooding Predictor, DE-FG36-00GO10521,

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Executive Summary

The primary goal of this project was to gain independent validation of the Distillation Column Flooding Predictor. This goal was achieved at the distillation pilot plant facilities of the Separations Research Program (SRP), Center for Energy and Environmental Resources, The University of Texas at Austin. In the SRP report titled "Performance Evaluation of the Pattern Recognition Flooding Predictor", researchers concluded;

"One major benefit of this software package (Flooding Predictor) is having the capability to run very close to the flood point, where the highest efficiency and highest capacity occur."

"Another positive aspect of the software package (Flooding Predictor) is that it can be installed on nearly any process control computer, in addition to and working with any other software packages already on the computer."

"The pattern recognition software works well with both packing and trays…"

"The Dzyacky Pattern Recognition Software maintained an average duty 99% of flood for the packed column and 99% of flood for the tray test with relatively few difficulties. Heat duty, and thus capacity, can remain higher for longer period of time."

A market survey conducted by New Horizon Technologies concluded that interest in the Flooding Predictor exists in the petrochemical industry. Feasible commercialization paths include partnering with and "industrial champion" of the technology, partnering with an established process control company, licensing to a technology vendor, or direct licensing to the end user.

The validation of the Flooding Predictor supports a small but growing body of knowledge in the area of non-traditional optimization techniques. The tests at the Separations Research Program demonstrated the technical effectiveness of the Flooding Predictor, and attracted the attention key industry leaders.

In 1Q 2002 I along with SRP investigators, presented the Flooding Predictor to a few major industrial sponsors of SRP. Our effort ultimately attracted the attention of Shell Global Solutions (US), Motiva Enterprises Inc., Fisher-Rosemount and CDTech. Together with the University of Texas and these four industrial partners, I submitted a proposal in response to the Office of Industrial Technologies, Chemicals Solicitation 2002. The proposal was funded in July of 2002 and I was awarded a DOE Cooperative Agreement in September of 2002.

The current Cooperative Agreement project titled The Distillation Column Flooding Predictor has four primary objectives; Pilot-plant demonstration at finite reflux, Dynamic Model Development, Commercial-scale validation, and Commercialization.

At this writing commercial-scale validation is underway at the Motiva Refinery in Norco, LA. The industrial partners have expressed a desire to license the Flooding Predictor if commercial-scale tests are successful.

Project Description

Technology Brief

The Flooding Predictor is an advanced process control strategy comprising a patented pattern-recognition methodology that identifies pre-flood patterns discovered to precede flooding events in distillation columns. The grantee holds a U.S. patent on the modeling system. The technology was validated at the Separations Research Program, The University of Texas at Austin under a previous grant from the U. S. Department of Energy, Inventions & Innovation Program.

Distillation tower flooding occurs at abnormally high vapor and/or liquid rates. The loss in tray efficiencies is attributed to unusual behavior of liquid inventories inside the column leading to conditions of flooding of the space in between trays with liquid. Depending on the severity of the flood condition, consequences range from off spec products to equipment damage and tower shutdown.

Benefits include low implementation and maintenance costs, and a high level of console operator acceptance. The previous commercial applications experienced 98% uptime over a four-year period. Further, the technology is unique in its ability to distinguish between different flooding mechanisms within the same tower, e.g., liquid and jet flooding.

Project Goals

This project had three major goals;

- Gain independent validation of the technology to demonstrate commercial applicability.
- Develop a technical training manual.
- Develop marketing tools.

Independent Validation

The primary goals of the project were achieved. The Flooding Predictor was independently validated a the distillation pilot plant facilities of the Separations Research Program (SRP), Center for Energy and Environmental Resources, The University of Texas at Austin. A series of tests were conducted at the SRP facility between April and June of 2001. The Flooding Predictor was tested on columns containing trays and structured packing. All tests were performed using a cyclohexane/n-heptane system.

The report from the Separations Research Program, "Performance Evaluation of the Pattern Recognition Flooding Predictor" concluded the following:

- The Flooding Predictor works well with both packed and trayed columns.
- The Flooding Predictor maintained an average duty 99% of flood for the packed column tests and 99% of flood for the trayed column with relatively few difficulties.
- One major benefit of the Flooding Predictor control strategy is having the capability to run very close to the flood point, where the highest efficiently and highest capacity occur.
- The Flooding Predictor can be installed on nearly any process control computer.

Further independent validation is taking shape at a Motiva refinery in Norco, Louisiana. As a result of the successful tests at the Separations Research Program, the Flooding Predictor attracted the attention of several industrial SRP sponsors; Shell Global Solutions (US), Fisher-Rosemount, CDTech and Motiva Enterprises Inc. These companies along with the University of Texas and the PI, successfully attracted further DOE funding in the form of Cooperative Agreement Number DE-FC07-02ID14426.

Technical Manual
A technical training manual on the Flooding Predictor was developed by Kitba Consulting Services, 2900 Wildcrest Drive, Suite 270, Houston Texas.

Marketing
The Flooding Predictor is achieving the desired market attention. The technology was presented at the Annual Meeting of the American Institute of Chemical Engineers (AIChE) in March of 2002. (The presentations given at AIChE were included in the Semi-Annual report on the Distillation Column Flooding Predictor dated 4/30/02.) The Flooding Predictor achieved recognition at the World's Best Technology 02 (WBT02) http://www.wbt02.com/. WBT02 was a sponsored jointly by The National Association of Seed Venture Funds, the Federal Laboratory Consortium for Technology Transfer and the Pittsburgh Technology Counsel. The Flooding Predictor was featured in the October 2002 Federal Laboratory Consortium Newsletter (attachment). The Flooding Predictor was featured in three newsletters of the Separations Research Program (attachment). The Flooding Predictor was also featured in the February issue of Fortune Small Business magazine in an article titled, "14 Hot Startups" (attachment).

Appendices

Appendix A.   Final Task Schedule

Appendix B.   Final Spending Schedule

Appendix C.   Final Cost Share Contributions (There were no cost-share contributions associated with this grant.)

Appendix D.   Energy Savings Metrics (For Energy Calculations see Chemical Project Evaluation, in Supplemental Information)

Supplemental Information

- Performance Evaluation of the Pattern Recognition Flooding Predictor; J. Christopher Lewis, A. Frank Seibert and James R. Fair, Separations Research Program, Center for Energy and Environmental Resources, The University of Texas at Austin.

- Chemical Project Evaluation; Energy Calculation Tool.

- Technical Manual on the Distillation Column Flooding Predictor.

- Separations Research Program Newsletter Fall 2001.

- Separations Research Program Newsletter Fall 2002.

- Separations Research Program Newsletter Spring 2003.

- Federal Laboratory Consortium for Technology Transfer Newsletter October 2002.

- OIT Chemicals IOF Project Assessment PI Questionnaire.

- OIT Chemicals IOF Project Review Assessment; AIChE Annual Meeting, New Orleans, March 2002.

- Fortune Small Business article, "14 Hot Startups", February 2003.

Appendix A

Final Task Schedule

Final Task Schedule

Task Number	Task Description	Task Completion Date				Progress Notes
		Original Planned	Revised Planned	Actual	Percent Complete	
1	Reestablish Commercial Viability External to BP/Amoco's Proprietary Applications	10/31/00		7/3/01	100%	Completed.
2	Submit Semi-annual Reports	On going			100%	Completed.
3	Develop Training/Technical Manual and Examples of Software Code	1/31/01		11/30/02	100%	Completed.
4	Develop Marketing Tools	01/31/01			100%	Completed.
5	Submit Final Report	10/30/02	05/31/03	05/31/03	100%	Completed.

Appendix B

Final Spending Schedule

Distillation Column Flooding Predictor

Final Spending Schedule   **Project Period:** 07/01/00 to 02/28/03

Object Class Categories	Approved Budget	Final Project Expenditures
Personal/Project Mgmt.	$25,000	$10,517
Fringe Benefits	$0	$0.00
Travel	$5,000	$2,171
Equipment	$2,600	$0
Supplies (Marketing; business cards)	$0	$580
Contractual (Independent validation at Separations Research Program, University of Texas at Austin) & (Development of technical manual, Kitba Consulting Inc.)	$20,300	$38,861
Construction	$0	$0
Total	$52,900.00	$52,129
DOE Share	$52,900	$52,129
Cost Share	N/A	N/A

Appendix C

Final Cost Share Contributions

Final Cost Share Contributions

| Funding Source | Approved Cost Share | | Final Contributions | |
	Cash	In-Kind	Cash	In-Kind
N/A				
Total				
Cumulative Cost Share Contributions				$0.00

Appendix D

Energy Savings Metrics

(For Energy Calculations see the Chemical Project Evaluation, in Supplemental Information)

Chemical Project Evaluation

▷ Project Details ▷ Market Selection ▷ Energy Impacts ▷ Environmental Impacts ▷ Summary

| Printable Page | View Projects | Edit Project | How To Save Results | Edit User Info |

User Name: CLEW
Project ID: 468

Project Summary

Project Name: **2NDPOINT-SRP OIT PROPOSAL**

User Inputs

Chain:	Broad Industry Sectors	% Energy Savings Feedstocks:	3.0%
Derivative:	Petrochemicals_and_Organics	% Energy Savings Heat/Steam:	5.0%
% of Market Impacted:	5.0%	% Energy Savings Electricity:	0.0%
Annual Growth Rate:	3.0%	Solid or Liquid Wastes:	25 lbs per 1000 lbs of product
Year of Introduction:	2003	Non-Combustion Air Pollutants:	0 lbs per 1000 lbs of product
Market Penetration Curve:	10 Year Market Saturation		

Energy Impacts for Broad Industry Sectors: Petrochemicals_and_Organics

(Based on the input provided above, this technology will have the following impacts:)

	2005	2010	2015	2020
MARKET PENETRATION	10.0%	50.0%	90.0%	98.8%
MARKET (Million lbs)	1,949	11,299	23,577	30,005
ENERGY SAVINGS				
Feedstock Energy Savings (trillion Btu)	0.157	0.909	1.897	2.414
Heat/Steam Energy Savings (trillion Btu)	0.454	2.633	5.494	6.991
Electricity Savings (trillion Btu)	0.000	0.000	0.000	0.000
POLLUTANT REDUCTIONS (lbs)				
Carbon (MMTCE/yr)	0.00709	0.04107	0.08570	0.10906

Nitrogen Oxides (NOX)	109,006	631,839	1,318,454	1,677,898
Sulfur Oxides (SOX)	59,045	342,246	714,162	908,861
Carbon Monoxide (CO)	24,526	142,164	296,652	377,527
Volatile Organic Compounds (VOCS)	2,407	13,953	29,116	37,054
Particulates	1,135	6,582	13,734	17,478
Other (million lbs)	49	282	589	750

N/A = not applicable

User Explanations

Technology Description: 2ndpoint and the Separations Research Program are submitting a proposal to the DOE for research funding of the distillation flooding predictor, a pattern recognition technology.

Market Percentage: Approximately 10% of distillation columns throughout the world have capacity issues that could be helped by this software.

Introduction Year: This is a software technology, so entry into the marketplace does not require any hardware to be manufactured. Initial testing will take place in 2002 and commercialization should soon follow.

Energy Impacts Percentages: Approximate energy savings through the reduction of energy wasted as a result of tower flooding and energy saved as effeciency is increased.

Other Wastes and Pollutants: off-spec product and greenhouse gases from electricity wasted and steam wasted

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