INTRODUCTION

➢ Background
➢ Technology
➢ Results
➢ Conclusions
➢ Acknowledgements
BACKGROUN

- The Inventor

George Dzyacky

- 25 yrs experience in petrochemical industry
- Obtained patent in July 1998
  - U.S. Patent number: 5,784,538
- Technology has operated on FCC, FCC main fractionators, stripper columns, and H₂S scrubber columns
TECHNOLOGY

- What is the Distillation Column Flooding Predictor (DCFP)?

- Control strategy that uses pattern recognition of process variables to prevent the column from flooding

- Non-intrusive signal processing technology

- A means of increasing throughput, reducing bottlenecks, and in some cases improving efficiency
TECHNOLOGY

- What are the applications?

- Approximately 40,000 distillation columns in the U.S. alone
  - 10% of these columns experience periodic flooding
  - Many of these towers are chronic flooders

- Tray Towers
- Packed Towers
TECHNOLOGY
- Is it proven?

- DCFP utilized in two closed loop FCC absorber columns
- DCFP used as an advisory system on three other columns
  - Two FCC Main Fractionator Columns
  - \( \text{H}_2\text{S Amine Stripper} \)
- DCFP implemented at the University of Texas on a tray tower and on a packed tower
TECHNOLOGY

Why is the DOE interested in this technology?

- DOE 2020 Strategy
  - DCFP could reduce energy consumption in the US by 9.4 Trillion BTU by 2020
- Industrial/Academic partnership
- Viable technology
TECHNOLOGY

Why should I be interested in this technology?

- Reduces downtime associated with column flooding
- Increases capacity and in some cases efficiency
- Effective on a variety of process
- Low capital and maintenance costs

BOTTOM LINE: $$$$
Tray Column

fraction of flood

weeping

entrainment

flooding

efficiency

0 0.2 0.4 0.6 0.8 1

2nd point
Packed Column

Flood Point

HETP, in

F-Factor, \((\text{ft/s})(\text{lb/ft}^3)^{0.5}\)

2nd point
TECHNOLOGY

- How does it work?

- DCFP uses existing DCS to calculate the derivatives of process variables
- DCFP compares derivative values to criterion entered by control engineers on site
- DCFP relaxes column severity by lowering the reboiler duty or another control mechanism
- DCFP enables the column to operate more efficiently and with more stability
TECHNOLOGY

- What is the key?

- “Critical Constants”
  - Discreet derivative values that are determined empirically
  - Comparison of current derivative values to the critical constants
    - Simultaneous occurrence
    - Values exceed user entered criteria
Numerous changes in tower variables, and all within normal alarm limits.
- pre-flood oscillations within normal alarm limits
TECHNOLOGY
- DCFP Column Variables

12:15
12:40
13:10
13:30

2ndpoint
TECHNOLOGY
-DCFP Derivative Values

PDT251 (pressure drop)

UPPER and LOWER dLT

dLT204 (reboiler level derivative)

dPDT251 (pressure drop derivative)

8 Fri Jun 2001

11:30 12:00 12:30 13:00 13:30 14:00

dLT204

dΔT_upper

PDT251

dΔT_lower

Secondary predictor

2ndpoint
PHASE 1 - Exploratory Work
- UT Austin SRP Pilot Plant
PHASE 1 - Exploratory Work
- UT Austin SRP Pilot Plant

- Experimental Work
  - Total reflux system
  - Cyclohexane/n-Heptane mixture
  - 24 psia
  - Trays
  - Structured Packing
PHASE 1 - Exploratory Work
-UT Austin SRP Pilot Plant - CONCLUSIONS

- DCFP validated by exploratory experimental work at SRP
  - Operated at 99% of measured flood
    - Trays and structured packing
  - Maintained efficiency
  - Further optimization necessary
  - Easy implementation on SRP’s Fisher-Rosemount Delta V DCS
PHASE 2 - DOE Grant
- Description of DOE Proposal

- $934,000 funding (50% DOE – 50% industrial sponsors)
  - UT Austin, Center for Energy and Environmental Resources
  - Shell Global Solutions (US)
  - Motiva Enterprises, LLC
  - CDTech
  - 2ndpoint
PHASE 2 - TEST PLAN
- Project Scheduling

- 2 year funding period
- Goals and Objectives
  - Pilot Plant Demonstration—UT Austin
  - Dynamic Model Development—UT Austin
  - Commercial Scale Validation—Motiva Refinery, Norco, LA
  - Commercialization
PHASE 2 - Pilot Plant Test Work
- UT Austin SRP Pilot Plant

- Dynamic holdup tests using 18” PVC Air/Water column
  - Column modifications
- Finite reflux tests using 18” distillation column
  - Significant equipment modification/upgrade
  - Trays
  - Packing
PHASE 2 - Pilot Plant Test Work
-Dynamic Holdup Experimentation

The Separations Research Program
The University of Texas in Austin

J. Christopher Lewis
Distillation Column Flooding Predictor

08/21/2001 Chris Lewis
DRW#03082120011

The Separations Research Program
The University of Texas in Austin

2ndpoint
Phase 2 - Control Methodology

- Temperature control (top tray/top packing) – Reflux Flow
- Temperature control (bottom tray/bottom packing) – Steam Flow to Reboiler
- Feed Flow Rate
- Feed Temperature
- Bottoms Level
- Bottoms Temperature
- Accumulator Level
- Column Pressure
## Phase 2 - Results

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**COMPOSITION (C6)**
Distillation Column Overview for 7.03gpm feed rate (maximum controllable loading with the Flooding Predictor in STANDBY). Curve 3 represents the pressure drop for this trend.
Distillation Column Overview for 7.11gpm feed rate (flood point with Flooding Predictor in STANDBY). Curve 3 represents the pressure drop for this trend.
Distillation Column Overview for 7.35gpm feed rate (Flooding Predictor in ACTIVE). Curve 3 represents the pressure drop for this trend. The dips in the pressure drop represent Flooding Predictor control.
Distillation Column Flooding Predictor for 7.35gpm feed rate (Flooding Predictor in ACTIVE). Curves 5 and 6 represent the Flooding Predictor response.
Distillation Column Overview for 7.55gpm feed rate (Flooding Predictor in ACTIVE). Curve3 represents the pressure drop.
Phase 2 - DCFP Conclusions

- Prevented tower flooding in both trays and structured packing
- Residence time affects critical constant values
- 6% increase in tray capacity while maintaining overhead and bottom compositions
ACKNOWLEDGEMENTS

- DCFP Project

- U.S. Department of Energy
- Motiva, LLC
- Fisher-Rosemount
- Shell Global Solutions
- CDTech
- 2ndpoint
- CEER, UT Austin
- **What is a column flood?**
  - **Entrainment (Jet) Flooding**
    - Occurs when the upward vapor velocity is high enough to suspend a liquid droplet
  - **Downcomer Backup Flooding**
    - Occurs when the backup of aerated liquid in the downcomer exceeds the tray spacing
  - **Mass Transfer Flooding**
    - Occurs when the liquid and vapor are not properly distributed (packed tower)
BACKGROUND

-What does a flood look like?