CCC Overview

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Presentation Overview

• What is surge?

• How does CCC control surge?
  – Deviation, Recycle Fast & Safety-On

• What is a Performance Controller?
  – Temp track & limit control

• CCC System Alarms
What is surge?

Compressor Map

Performance curve for a specific speed N1

Pressure

Flow

Operating Point

N_{\text{min}}

N_{\text{max}}

Q_1

P_1
What is surge?

- $P_d$ rises
- delta-P across compressor rises
- Compressor loses ability to make pressure

Operating point moves up the curve
What is surge?

- Flow reverses
- delta-P across compressor drops
- Compressor moves back to stable region
- Cycle starts again...

Operating point ‘jumps’ from +ve and -ve flow
What is surge?
What is surge?

- Rapid flow swings
- Thrust reversals
- Rapid pressure swings & instability
- Rising temps inside compressor
**What factors lead to surge?**

- Start-up / Shutdown
- Reduced throughput
- Abnormal conditions
  - Trips
  - Power loss
  - Load changes
  - Cooler problems
  - Turbine problems
  - Operator error
  - Process Upsets
  - Gas composition changes
  - Filter / strainer problems
How does CCC control surge?

• The Challenge
  – Most efficient operating point is just before you reach surge. How do you measure your proximity to surge accurately so we can run as close as possible to the surge limit?

• The Solution
  – Invent a number called ‘deviation’ that is only dependent on flow / pressure / temperature
How does CCC control surge?

Most OEM head-flow curves are dependent on many factors e.g. Molecular Weight

Vendor head-flow curves

Reduced head-flow curves
How does CCC control surge?

By using reduced (standardised) values the Surge-Limit-Line and Surge-Control-Line can be defined.
How does CCC control surge?

- **DEVIAITION**
  - Arbitrary number that says how far from the Surge Control Line we are operating
  - Dev = 0 when on the control line
  - Dev = +ve when moving away from surge
  - Dev = -ve when moving towards surge

  - Ranged from -1 to +1
How does CCC control surge?

- Control Scheme
  - If Dev > 0, close recycle valve
  - If Dev < 0, open recycle valve
  - Normal PI control, just like any other loop
How does CCC control surge?

- Recycle Fast
  - If deviation moves quickly towards surge, CCC gives the valve a ‘kick’

* Holds the last value for 2.5 sec!
How does CCC control surge?

- **Safety-On**
  - Compressor has surged or a very low deviation
  - *No additional valve response*
  - Moves the Surge Control Line further to the right
How does CCC control surge?

- Typical response:
CCC Control Points

STL: Surge Trip Line
SOL: Safety-On Line
RTL: Recycle-trip Line
SCL: Surge Control Line
TSL: Tight Shut-off Line

Speed curves

(-0.4) (-0.2) (-0.1) (Dev = 0) (Dev = 0.15)
STL  SOL  RTL  SCL  TSL
• Tight-shutoff line (Dev ~ 0.15)
  – Valve is clamped down onto seat, low risk of surge
• Surge-Control line (Dev = 0)
  – PID control of valve at dev = 0
• Recycle-trip line (Dev ~ -0.1)
  – Steps open valve about 10 - 15%
  – Holds the valve for about 2.5s
  – Poor response of valve can lead to trip!!
• Safety-On line (Dev ~ -0.2)
  – Moves all lines to the right & increments surge count
  – Valve steps open due to PID response
• Surge Trip line (Dev ~ -0.4)
  – Would expect compressor to be surging
  – 3 surges in 6 seconds will trip compressor
Performance Controller

- Used to control compressor throughput
  - blow-off
    - used more for plant air systems
  - discharge throttling
    - inefficient
  - suction throttling
    - often used on electric-drive compressors
  - compressor guide-vane control
    - efficient
  - speed variation
    - Used in Domgas & LNG
Performance Controller

- Limit Control
  - Ensures a physical constraint is not exceeded.
    E.g:
    - Pd max of 2350kPa on K1440 discharge

- Temp tracking:
  - Mark IV or V may limit on EGT
  - CCC designed to ‘track’ speed
    - provides bumpless transfer back to CCC control
  - Historically, has provided problems
    - Incorrectly tuned
Load Sharing

- Regulate capacity & maximise efficiency
- Provides control of a network
Load Sharing

- Comprises of two types of response:
  - Primary Capacity Control
    - Manipulates a variable by adjusting speed / recycle
      - e.g. Suction pressure on K30
    - ‘visible’ load-sharing response
  - Load-balancing
    - Ensures both compressors operate in the same region
      - i.e. minimise un-necessary recycle
    - De-couples response of the anti-surge & performance controllers
Load Balancing

- **Equidistant control**
  - Compressors in series
    - Equalise normalised compression ratio
    - Used on LNG MR and C3 circuits
  - Compressors in parallel
    - Equalise recycle deviation
    - Used on Domgas K30
    - Note: Domgas K20 load-sharing performed in DCS
Loadsharing control scheme

Primary Capacity Control (e.g. Suction pressure)

Antisurge Controller
- Mode
- PI
- RT
- DEV
- Loop Decouple
- To recycle valve

Loadshare Controller
- Primary Response
- Loop Decouple
- DEV
- To Speedtronics

Master Controller
- PV
- SP
- PID
- DCS setpoint

Analog inputs

To recycle valve
**CCC System Alarms**

- Historically, not much information available on DCS
  - Application faults & hardware faults only

- New alarms utilise graphics to display origin of a fault
  - Any CCC alarm should be referred back to the graphic
### CCC System Alarms

- **Tag convention**

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<th>XCC</th>
<th>04</th>
<th>1</th>
<th>1</th>
<th>A</th>
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</thead>
</table>

- **CCC System Alarm**
- **FAR #**
- **Card #**
- **Cabinet #**
- **Tag Type descriptor**
How does CCC send alarms?

• Any event causes an alarm
  – Each alarm has a criticality and location
  – Hit the ‘acknowledge’ target on the graphic
    • If the alarm goes away, the fault has cleared
    • The criticality will remain until an Inlec has investigated
      – Most alarms require no further action apart from a workorder

• New faults will now be able to initiate the alarm
  – Application faults have a ‘look-up’ table
  – Refer to the Control Instructions for more info!
Fallback Alarm

• This alarm means CCC has lost the ability to control
  – e.g. lost both flow transmitters

• Response:
  – Recycle valve opened in manual to approx 50%
  - exact amount depends on the controller setting
    – minimum flow required to stay out of surge for all conditions
  – Performance controller goes to manual at last OP