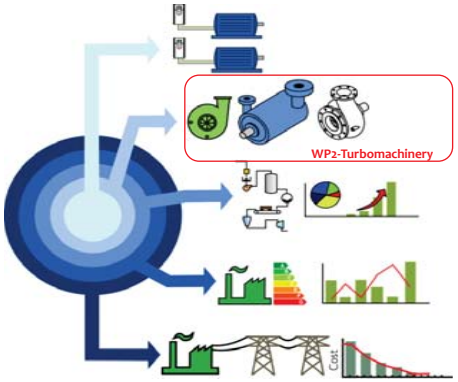
Energy-SmartOps

Integrated Control and Operation of Process, Rotating Machinery and Electrical Equipment

Turbomachinery – Work Package 2

Imperial College London & BASF SE The Chemical Company

WP2 in Energy-SmartOps

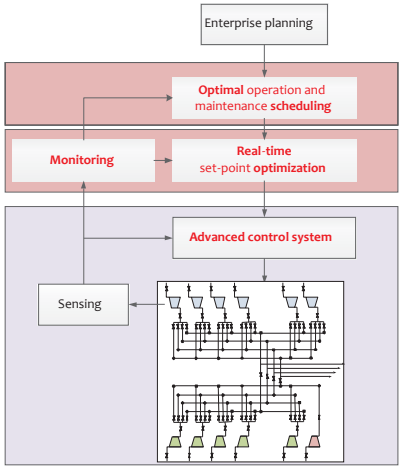


Fault diagnosis
Equipment monitoring
Advanced control
Parameter identification
Real-time optimization
Maintenance
Scheduling
Optimization
Process industries

Obj1: Develop scalable and complete equipment monitoring systems✓

Obj2: Devise new algorithms for overall performance monitoring and control✓

Obj3: Study ways that energy savings can be achieved✓



"To reduce the energy usage

for gas compression, we need

smart ways to operate compressors!"

1. Models of the compressors translate experimental observations into a mathematical formulation suitable for Control, Monitoring and Optimization applications
2. Monitoring algorithms implement physical knowledge to reveal gradual degradation and prevent gross failures
3. Optimization frameworks make use of monitoring information to systematically increase the system efficiency and reduce the overall energy requirement
4. Advanced control systems implement the results of the optimization ensuring the achievement of the optimization potential while respecting safety constraints

Matteo Cicciotti — BASF SE

Adaptive monitoring of heath-state and performance of centrifugal compressors

M. E. Barrera-Medrano — Imperial College London

Aerodynamic impact of fouling in centrifugal compressors

Dionysios P. Xenos — Imperial College London

Optimization of centrifugal compressors operation and maintenance

Sara Budinis — Imperial College London

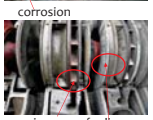
Control systems for centrifugal compressors

Adaptive monitoring of heath-state and performance of centrifugal compressors

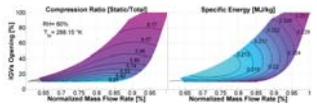
- A framework was investigated and devised to model the performance of compressors by means of physical aerodynamic relationships.
- A monitoring algorithm was developed that incorporates these models and can detect and predict the effect of fouling, erosion and corrosion on the performance
- The degradation effects were investigated on-site on an industrial compressor
- The monitoring information are used by D. Xenos in its condition-based optimization framework
- The technology has been validated successfully and the first industrial prototypes have been commissioned

BASF SE compressor as case-study

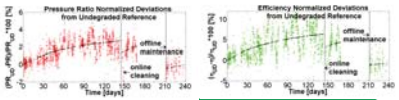

corrosion


erosion fouling

Automatic generation and update of performance maps from industrial process data



Online detection of performance reductions due to degradation



Aerodynamic impact of fouling in centrifugal compressors

"Fouling is the build up of material inside the compressor. "

The main consequences are: **reduction in flow capacity, reduction in pressure ratio and efficiency**; and therefore a **reduction in operation range.**

Research Aim: this research will allow detection and evaluation of present fouling along with its effects on the compressor performance parameters, defining when the compressor should be cleaned towards its optimum.

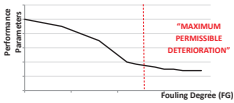
Performance parameters

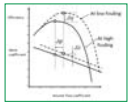
$$(\lambda, \phi, \eta) = f(FG)$$

$$\lambda = f_1(FG)$$

$$\phi = f_2(FG)$$

$$\eta = f_3(FG)$$





Material and methods:

1st approach: influence of different fouled conditions on the performance parameters of the compressor .

2nd approach: influence of different fouled conditions over blade suction side/pressure side on the performance parameters of the compressor.

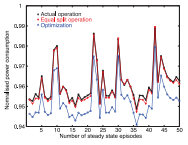
3rd approach: real fouling injection in order to study the location and its influence on the performance parameters of the compressor under different operation conditions.

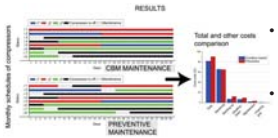

Imperial testing facility

Optimization of centrifugal compressors operation and maintenance

The focus is on multiple compressors operating in parallel considering the overall plant (optimization of the system rather than one unit).

- A Real Time Optimization (RTO) scheme reduced the power consumed compared to typical industrial strategies.
- The RTO was applied to a 12h operation.
- The RTO receives the configuration of the compressors from the solution of scheduling.





- The Condition Based Maintenance optimization reduced the overall costs compared to a typical preventive strategy.
- The integration of condition monitoring and scheduling has given the first results.

Control systems for centrifugal compressors

INTRODUCTION:

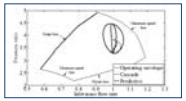
The focus of this project is on control and operation of centrifugal gas compressors for carbon dioxide application

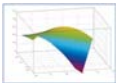
MOTIVATION:

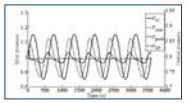
- The integration of capacity and antisurge control can reduce oscillation and instabilities while guaranteeing a better control of the overall system
- The antisurge recycle loop plays a key role in the dynamic of the system and can affect the response of the control system action
- The compression of carbon dioxide to supercritical condition needs to take into account the high density of the gas, especially during antisurge recycle

RESULTS:

- The performance of the capacity controller was improved by proposing a control system based on the map of the compressor. At the same time the proximity to surge during transient was reduced
- The analysis of the gas recycle has shown the influence of the gas condition on the control system response







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Energy-SmartOps consortium investigates equipment and process monitoring, integrated automation and optimization for energy savings.

http://www.energy-smartops.eu/