Energy Management
Optimal Byproduct Gas Distribution in Iron and Steel Making Plants
Energy-rich (~ 700 – 4300 Kcal/Nm³) byproduct gases are generated in large volumes during iron- and steel-making processes.

Byproduct gases are consumed by iron- and steel-making processes and also to generate power in captive power plants.

Gas network may consist of gas mixing stations, compressors etc.
Byproduct Gas Management

Challenges

1. Uncertain and irregular byproduct gas generation patterns

2. Limited gas storage capacity leads to temporal imbalances in gas demand and supply

3. Momentary excess of a byproduct gas results in flaring and hence economic loss

4. Operating pressures of different gases may introduce flow and mixing limitations for gases

5. Large and complex gas networks, various operation constraints, unplanned operation scenarios result in sub-optimal performance of the gas energy network
Gas Management Solution
Optimization of Gas Distribution

- Capable of handling large and complex iron and steel plant gas networks
- Robust solution for various operational scenarios like unplanned plant stoppages
- Gas mixing stations and compressors are considered in the solution
- Generates optimal planning schedule for gas distribution
- Capable of re-scheduling based on changes in supply and demand patterns of gases
- Possibility of simulating various operation scenarios and gas distribution schedules
Gas Management Solution Strategy
Model Predictive Control Technology

Future prediction and Optimization

**Inputs**
- Gas Generation profile
- Demand profiles of consumers

**Outputs**
- Future plan and schedule of gas distribution
- Provides which gas and in what amount to be supplied to each consumer

- Dynamic mathematical models for gas holder level predictions
- Theory of propositional calculus and mathematical representation of logical relationship
- “Branch and Bound” optimization technique to solve Mixed Integer Linear Programming (MILP)
- State-of-the-art commercial solver “cplex” from ILOG to solve gas optimization
Gas Management Solution

Workflow

- **Understanding customer’s gas network**
  - Each gas network is unique
  - Understand operation strategies and limitations

- **Mathematical representation of gas network**
  - Represent gas network with dynamic mass and energy balance models

- **Formulating logical constraints**
  - Include logical heuristics or constraints in the gas network model, e.g. due to compressors, gas mixing stations etc

- **Prediction of gas generation patterns**
  - Utilize historic operation data to predict the generation patterns for gases based on production schedules

- **Gas network Optimization and generation of plan**
  - Gas Optimization problem is solved and gas distribution plan is generated for operators
Feasibility study carried out on a gas network of an integrated iron and steel plant

- Blast Furnace Gas, Corex Gas, LD Gas, Coke Oven Gas network

Manual operation of gas network results in excessive flaring of byproduct gases

- 5 – 10 % Blast Furnace Gas flaring;
- 0.5 – 1 % Coke Oven Gas flaring
- 1.5 – 2 % Corex Gas flaring

Gas network consist of 2 gas mixing stations

Byproduct gases supplied to Captive power plants and external power plants

~ 50 byproduct gas consumers were considered
Case Study
Results

- Gas management solution computes optimal gas supply schedule
- For a particular consumer, results provide
  - Type of gas
  - Quantity of gas
  - Duration of supply of gas
- Optimal gas supply schedule result in minimal energy loss
Gas Management Solution
Expected Benefits

Benefits for 8 MTPA integrated iron- and steel-making plant

- ~ 50% reduction in gas flaring
- ~180,000 Gcal energy savings per year
- 2 to 5 MUSD savings per year
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