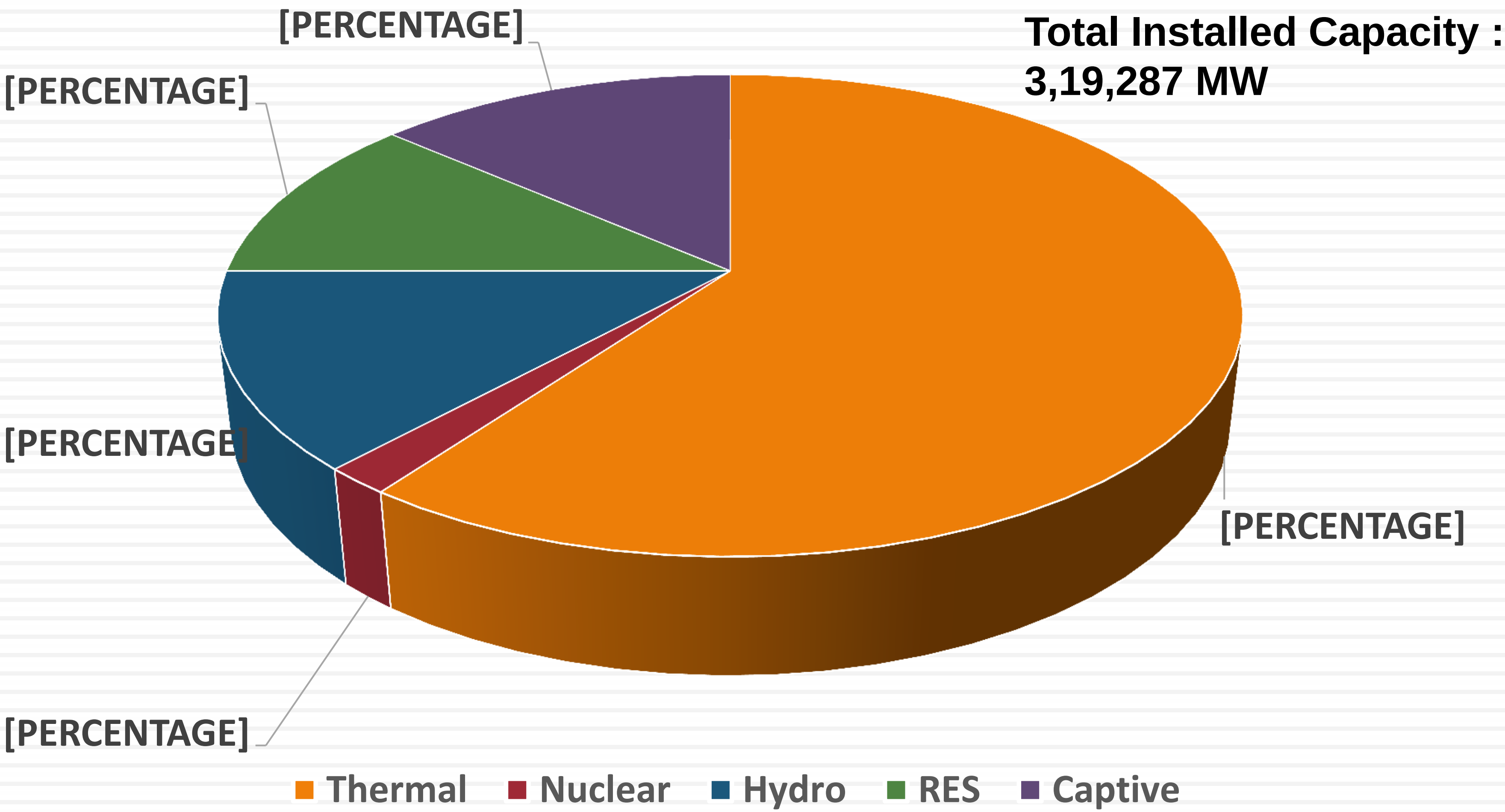
BEST PRACTICES IN THERMAL POWER PLANT

Confederation of Indian Industry
CII – Godrej Green Business Centre, Hyderabad, India

Agenda

- Indian Scenario – Power Plant
- Factors affecting Power Plant Performance
- Case studies

All India Installed Capacity (MW)



Source : As on 31-07-2015, CEA Website

APC % - Thermal Power Plant Scenario

Sl. No	Operating Capacity, MW	APC %
Plant A	250	8.20
Plant B	135	9.63
Plant C	60	8.19
Plant D	250	9.20
Plant E	130	6.99
Plant F	300	7.92
Plant G	150	8.23
Plant H	300	9.36
Plant I	125	13.10

APC % - Captive Power Plant Scenario

Sl. No	Operating Capacity, MW	APC %
Plant A	06	13.5
Plant B	15	9.82
Plant C	15	7.73
Plant D	15	7.57
Plant E	18	7.80
Plant F	25	8.15
Plant G	25	10.95
Plant H	27	7.69
Plant I	30	6.96
Plant J	33	11.0

- Thermal power plants
  - APC % ranges : 8 – 12.5%
    - Large Bandwidth
- Example:
  - Installed capacity :163304 MW
  - Operating Capacity : 130643 MW @ 80% PLF
  - APC power : 11104.6 MW @ 8.5% APC (average)
- At least 0.5% reduction in APC%
  - Huge increase in the Net Power Generation
    - Approx. 653 MW

CII

- Captive power plants
  - APC % ranges : 5 – 12.5%
    - Large Bandwidth
- Example:
  - Installed capacity :34444.12 MW
  - Operating Capacity : 27555.3 MW @ 80% PLF
  - APC power : 2342.2 MW @ 8.5% APC (average)
- At least 1% reduction in APC%
  - Huge increase in the Net Power Generation
    - Approx. 275 MW

APC% Benchmarking - AFBC boilers

Sl. No.	Auxiliary Name	Specific Power Consumption, kW/MW
1	Fans (PA, SA, ID & ACC fans)	17.9
2	Pumps (BFP, CEP, & ACWP)	24.6
3	BOP (WTP, CHP, ESP, Lighting, AC, CHP, Compressors & Misc.)	11.1
	Total	53.6 (APC – 5.36%)

CII

APC% Benchmarking - CFBC boilers

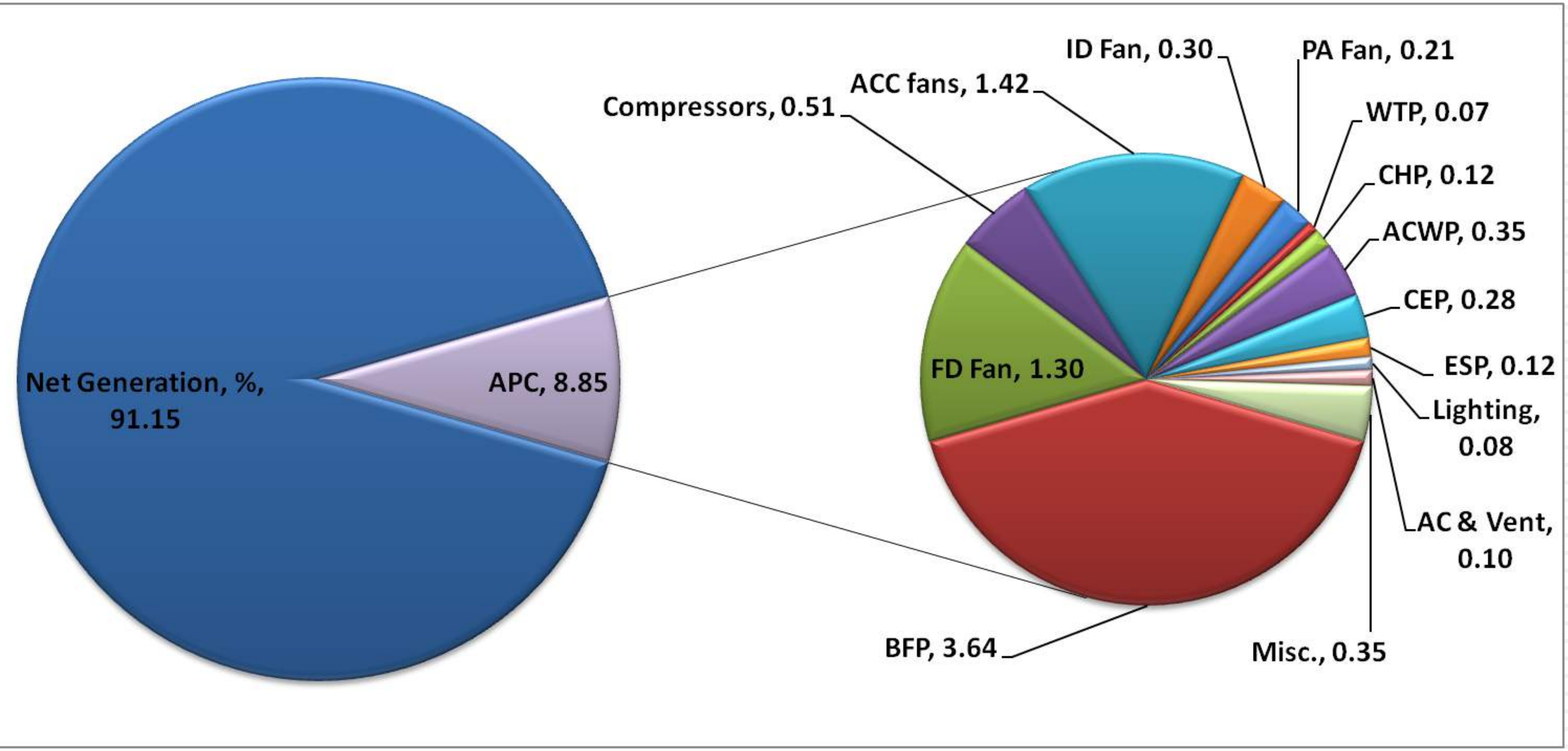
Sl. No.	Auxiliary Name	Specific Power Consumption, kW/MW
1	Fans (PA, SA, ID & ACC fans)	29.79
2	Pumps (BFP, CEP, & ACWP)	25.74
3	BOP (WTP, CHP, ESP, Lighting, AC, CHP, Compressors & Misc.)	9.83
	Total	65.36 (APC – 6.53%)

CII

Factors affecting Power Plant Performance

- **Overall Plant Heat Rate**
  - Plant Load Factor
  - Operational efficiency of the equipments
  - Startup & shutdown
  - Age of the plant
  - Fluctuation load
  - Coal quality

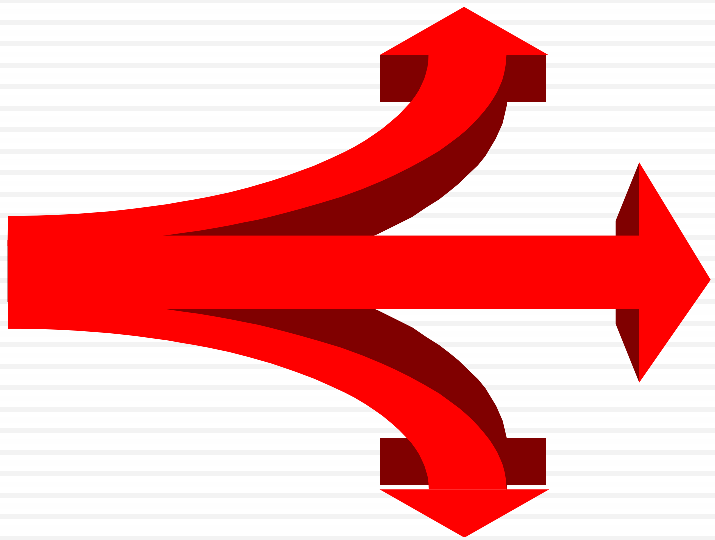
Typical APC % Breakup



Energy Conservation at macro level…

Capacity utilization

Three-pronged approach



Fine-tuning

Technology up gradation

Best Practices

Optimise the operation of CEP

- Condensate extraction pump
- Operating with the valve controlling
  - Deareator level is controlled with the control valve
    - Pressure drop across the control valve is 5 – 8 kg/cm^2
- Recirculation valve is 90% closed
  - But 12.8 m^3/hr is passing through recirculation line
- Good potential to optimise the CEP operation

CII

Optimise the operation of CEP

- Recommendation
- Option 1 :
  - One stage blinding
- Option 2:
  - Install VFD
  - Interlock the VFD with the condenser level and operate it in closed loop
  - Open the control valve fully
  - Maintain “ZERO” recirculation
  - Atleast 3.0 kg/cm^2 reduction in the discharge pressure

Optimise the operation of CEP

Annual Saving	-	Rs 40.0 Lakhs
Investment	-	Rs 15.0 Lakhs
Investment	-	5 months

Operate condenser vacuum at design vacuum level

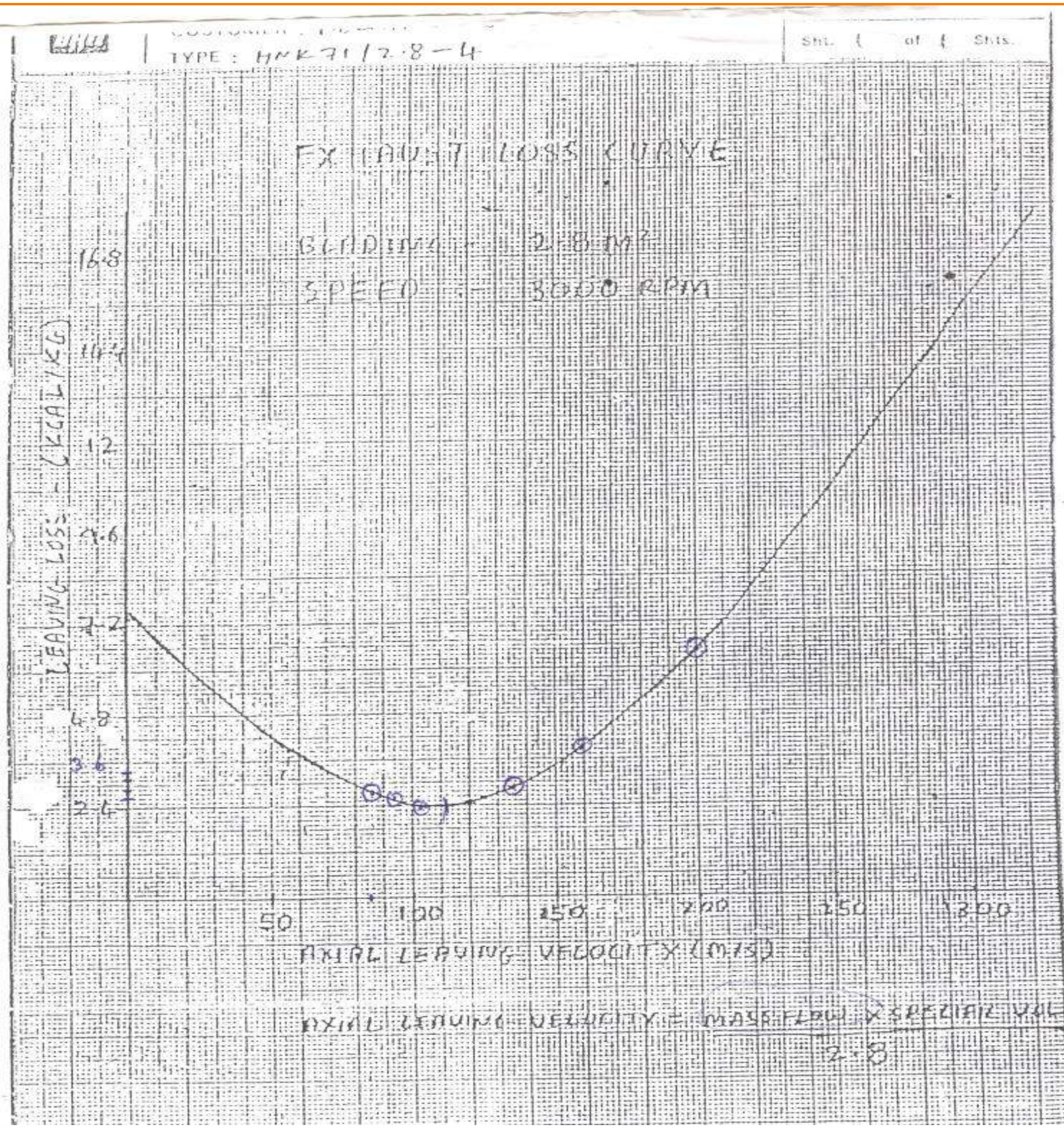
- What is the effect of vacuum on turbine performance?
  - Turbine capacity : 250 MW
  - Present operating Load : 115 MW
- Load less than 50% of the capacity
- During normal operating condition very low vacuum has been achieved
  - Achieved vacuum : 0.04 kg/cm^2 (a)
  - Design vacuum : 0.1 kg/cm^2 (a)

CII

Operate condenser vacuum at design vacuum level

- Effect of lower vacuum compared to the design
- Life of turbine
  - Reduction in dryness fraction of exhaust steam
    - Turbines normally design for 0.88 dryness fraction
  - Increased pitting on LP turbine blades
- Increase in energy consumption
  - Velocity of steam flow increases
  - Exhaust loss increases

Turbine Exhaust Loss Curve



Operate condenser vacuum at design vacuum level

Pressure (kg/cm^2)	Velocity (m/sec)	Exhaust loss kCal/kg
0.1	85	2.8
0.09	93.8	2.5
0.08	104.8	2.4
0.06	137.5	3.0
0.05	163	3.8
0.04	201	6.5

Operate condenser vacuum at design vacuum level

- The exhaust loss is the lowest at 0.08 kg/cm^2 (a) vacuum
- How to maintain the design vacuum
  - Reduce the quantity of water supply
  - Optimise the operation of cooling tower fan
- Equivalent reduction in steam consumption – 300 kg/hr

Annual Saving	**-**	**Rs 27.00 Lakhs**

CII

Heater performance Improvement

- HP & LP heaters – improves overall efficiency of the plant
- HP heater performance
  - More important compared to LP heaters
  - Marginal reduction in performance – significantly increases the heat rate
  - During normal operating condition – Difficult to identify the deterioration

HP Heater performance Improvement

- Key parameters indicating performance of the heaters
  - Economizer inlet feed water temperature
  - Terminal temperature difference (TTD)
  - Drain cooler approach (DCA)
  - Steam flow through HP heater – to be estimated based on heat balance

Definition of key parameters

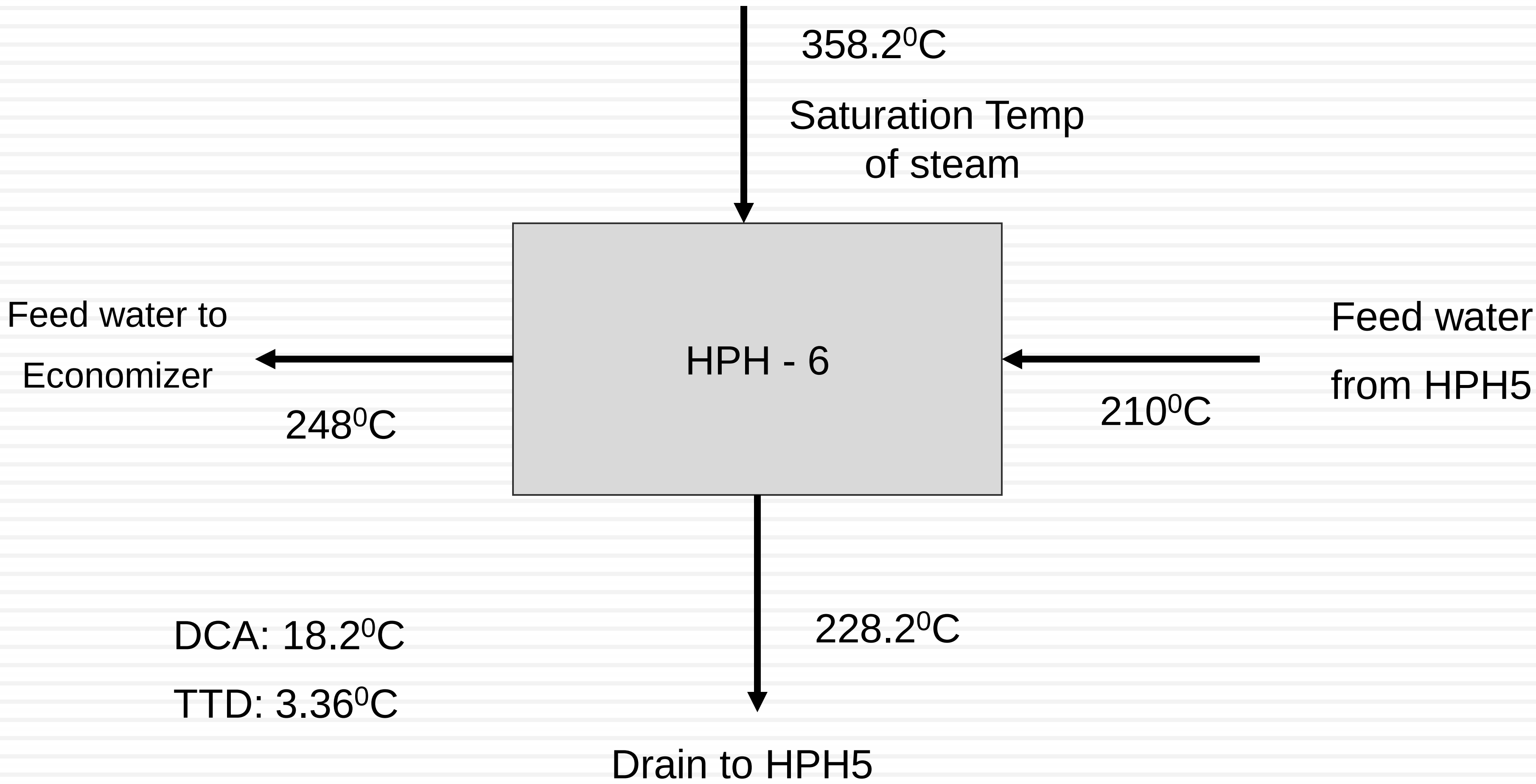
- Terminal temperature difference
  - Temperature difference between heater outlet feed water temperature and the saturation temperature of steam

    TTD = Tsat – Tfwo

- Drain cooler approach
  - Temperature difference between drain temperature and inlet feed water temperature

    DCA = Tdrain - Tfwi

Heater performance improvement – Case study



DCA: 18.2⁰C

TTD: 3.36⁰C

Heater performance improvement

UNIT	HEATER	OPETATING		DESIGN	
		DCA	TTD	DCA	TTD
1	HPH6	11.6	3.37	6.8	2.6
	HPH5	2.4	7.00	6.8	2.6
2	HPH6	18.2	3.36	6.8	2.6
	HPH5	5	7.21	6.8	2.6

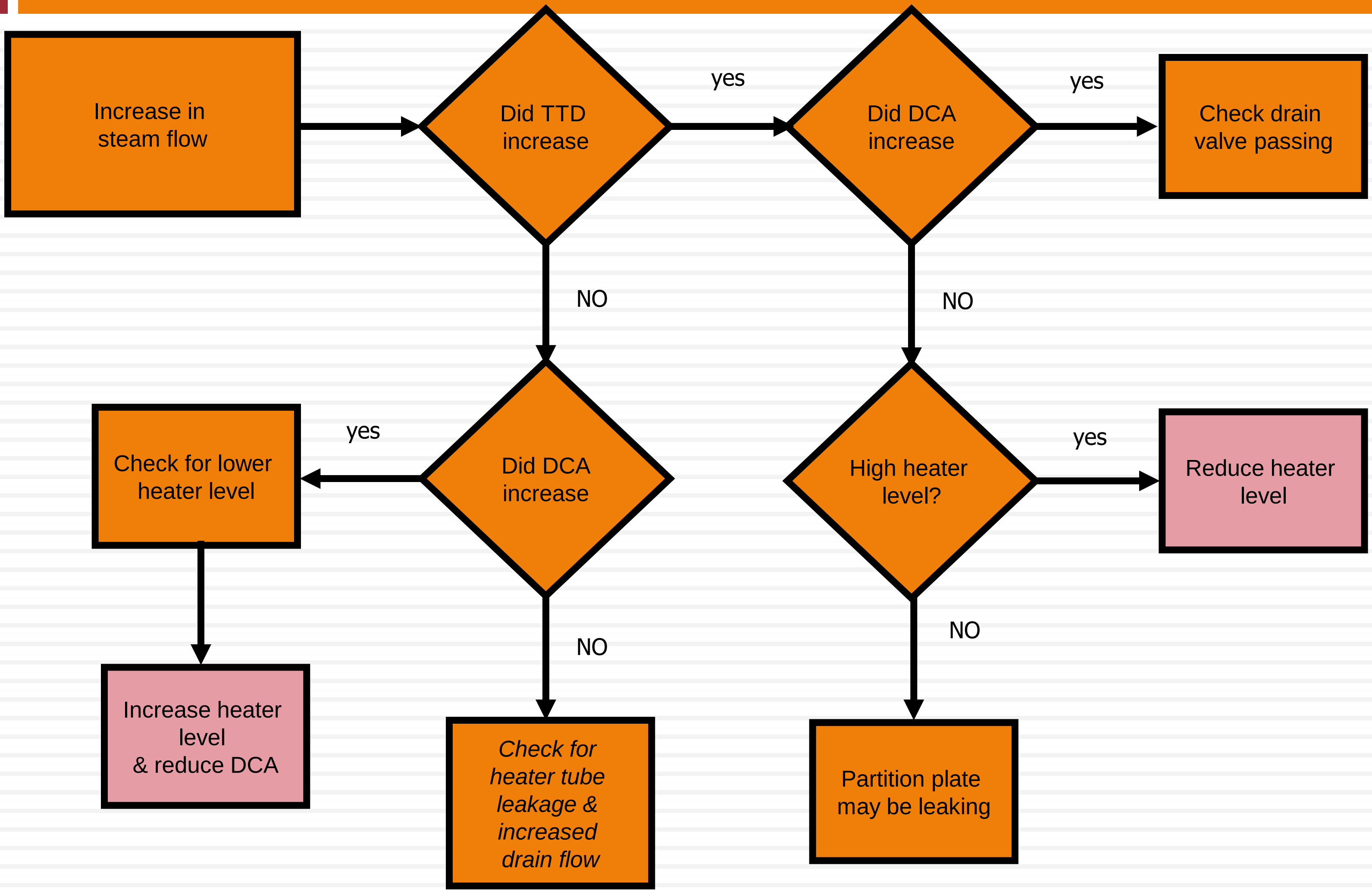
Heater performance improvement

- Observations
  - Quantity of steam flow is also high compared to design in HPH – 6
  - Drain cooler approach is very high compared to design
  - Marginal increase in TTD
- Possible reasons
  - Performance of HP heater
  - Passing of drain valve

Heater performance improvement

- Drain valve to deaerator leaking
- Replace the existing drain valve preferably with multi stage pressure reduction drag valve
  - Avoid passing

Guide line for heater performance improvement

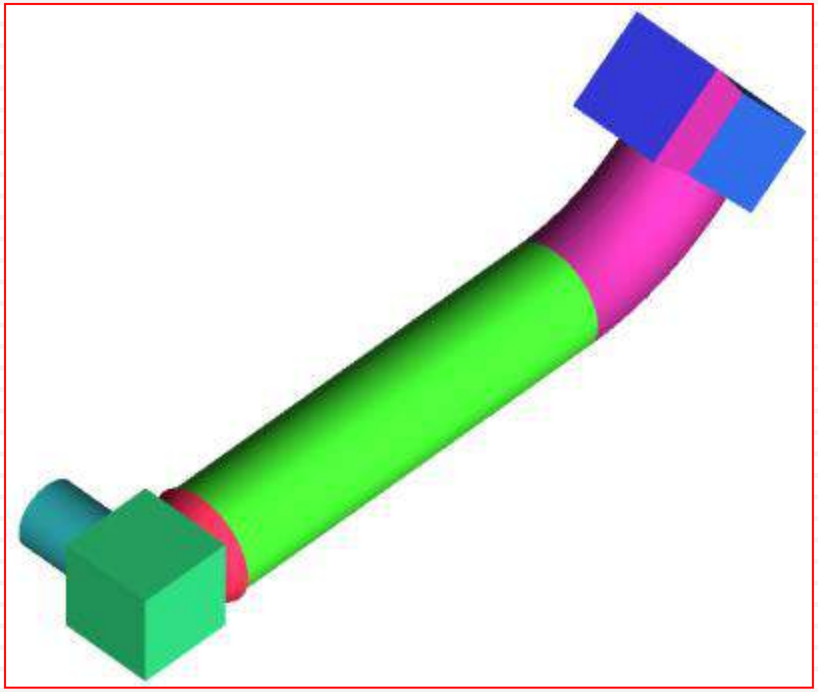


Optimise the pressure drop in flue gas circuit

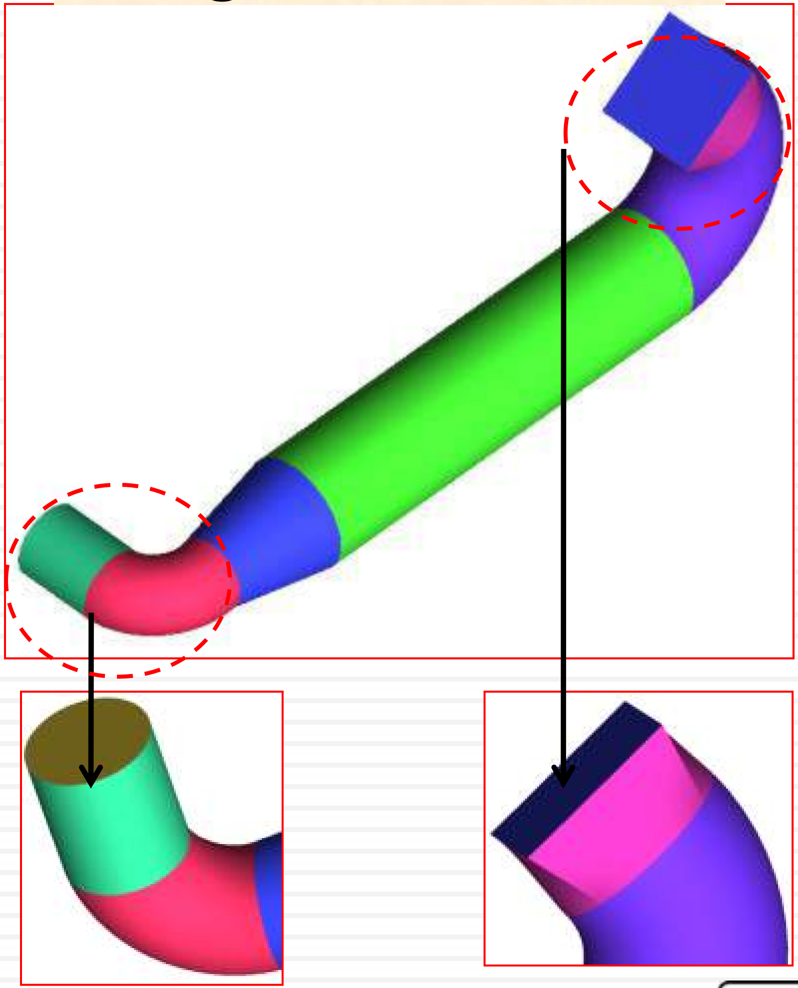
- Static pressure measurement in the flue gas circuit
  - Pressure drop across APH, Economiser & ESP
    - 120 – 135 mmwc across each section
  - Calculated flue gas velocity
    - 6 – 18 m/sec
- Possible reasons are
  - Due to duct bends (90^0)
  - Due to improper distribution of the flue gas
  - Turbulence in flue gas path
- Standard Norm (Pressure drop):
  - APH & Economiser – 60 – 80 mmwc
  - ESP – 15 - 25 mmwc

CFD Model

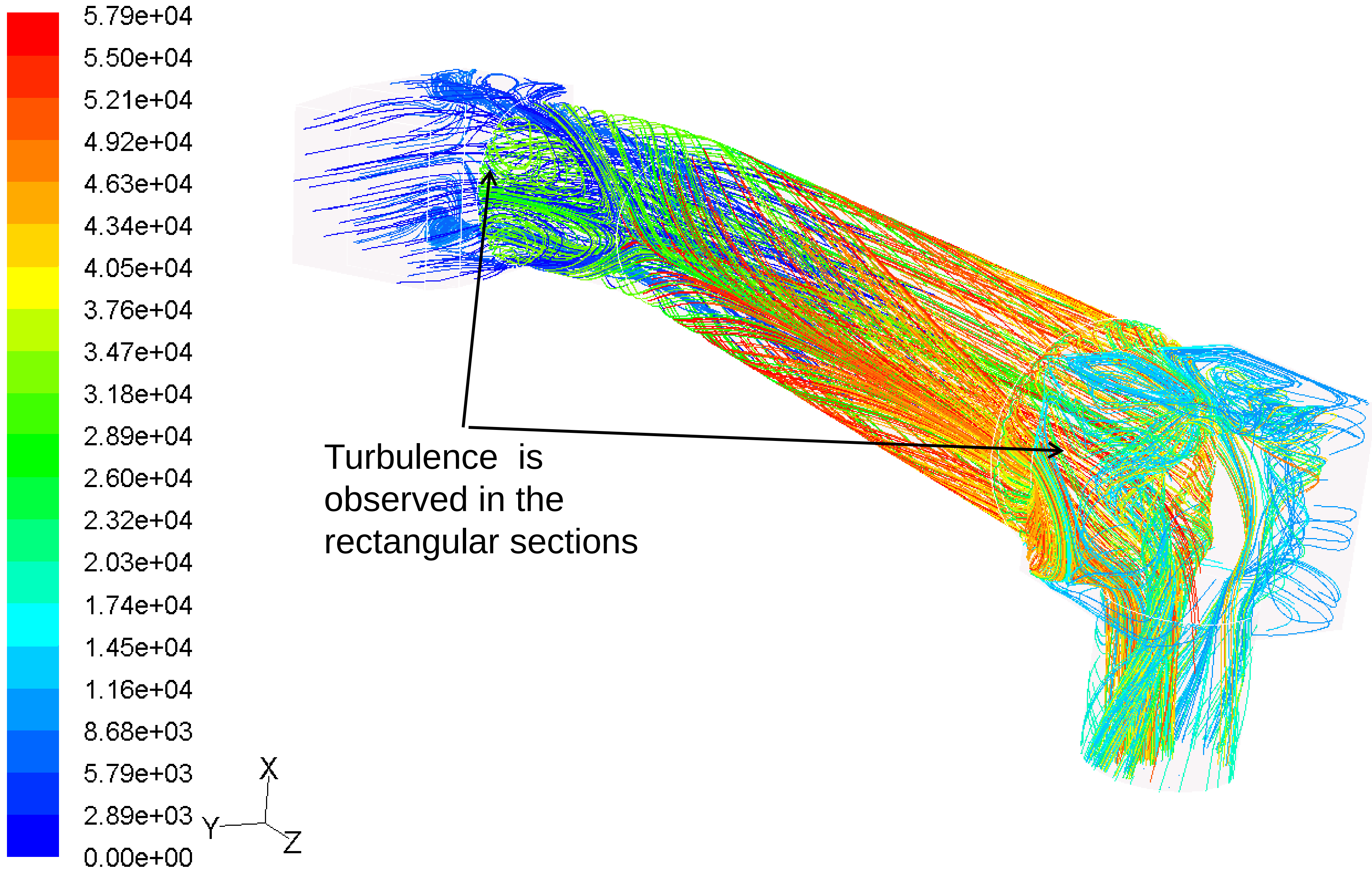
AS IS



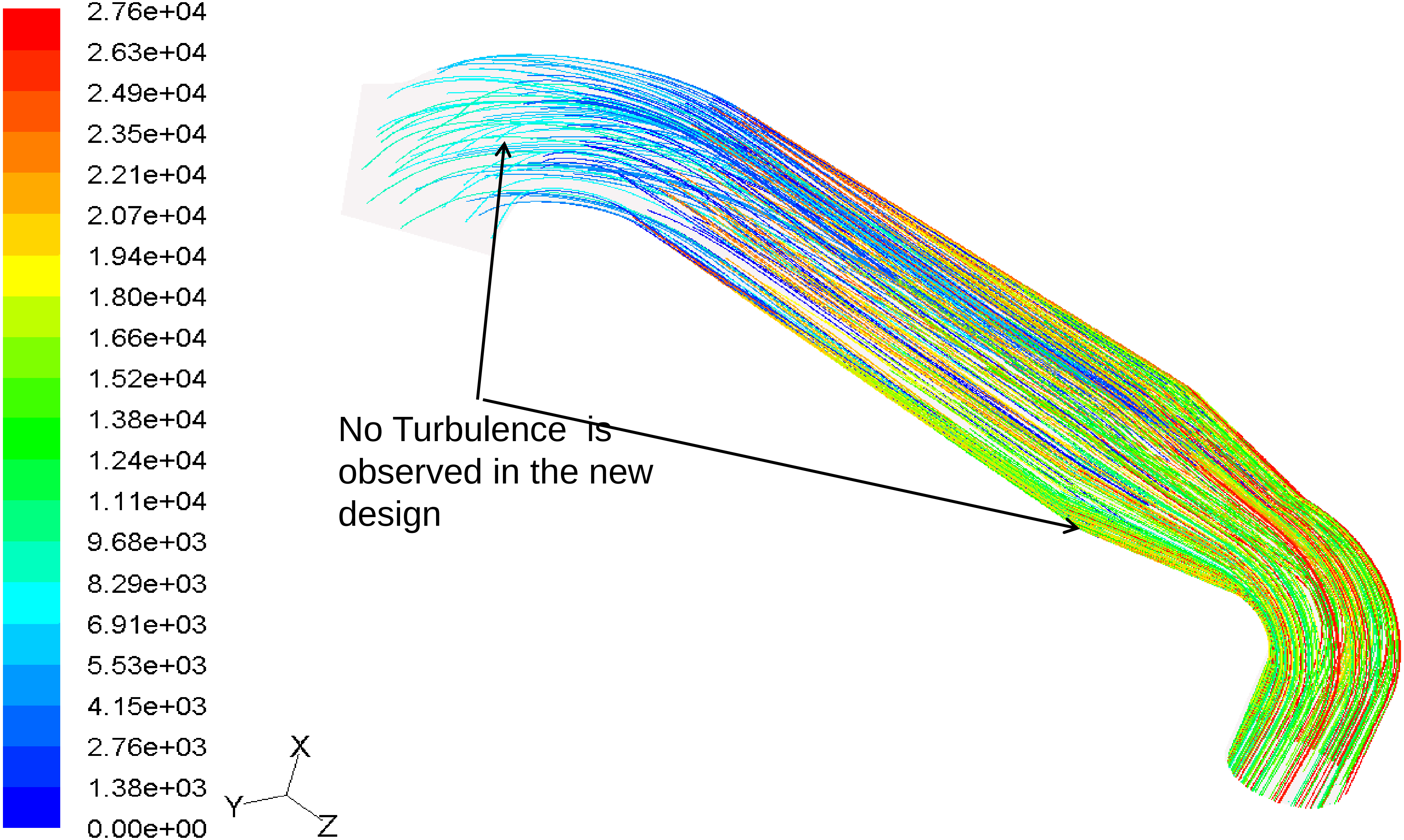
Design Modification



Path Lines Colored by Velocity Magnitude AS IS



Path Lines Colored by Velocity Magnitude NEW DESIGN



CFD Application

- Pressure drop reduced by 50 %
- Excellent potential for energy   saving
  - Low investment & downtime
- Further areas for CFD Application
  - Ducts, ESP, Cyclones– return dust loss & ΔP
  - Optimization of separators & Bag House - cement

© Confederation of Indian Industry

Optimise the pressure drop in flue gas circuit

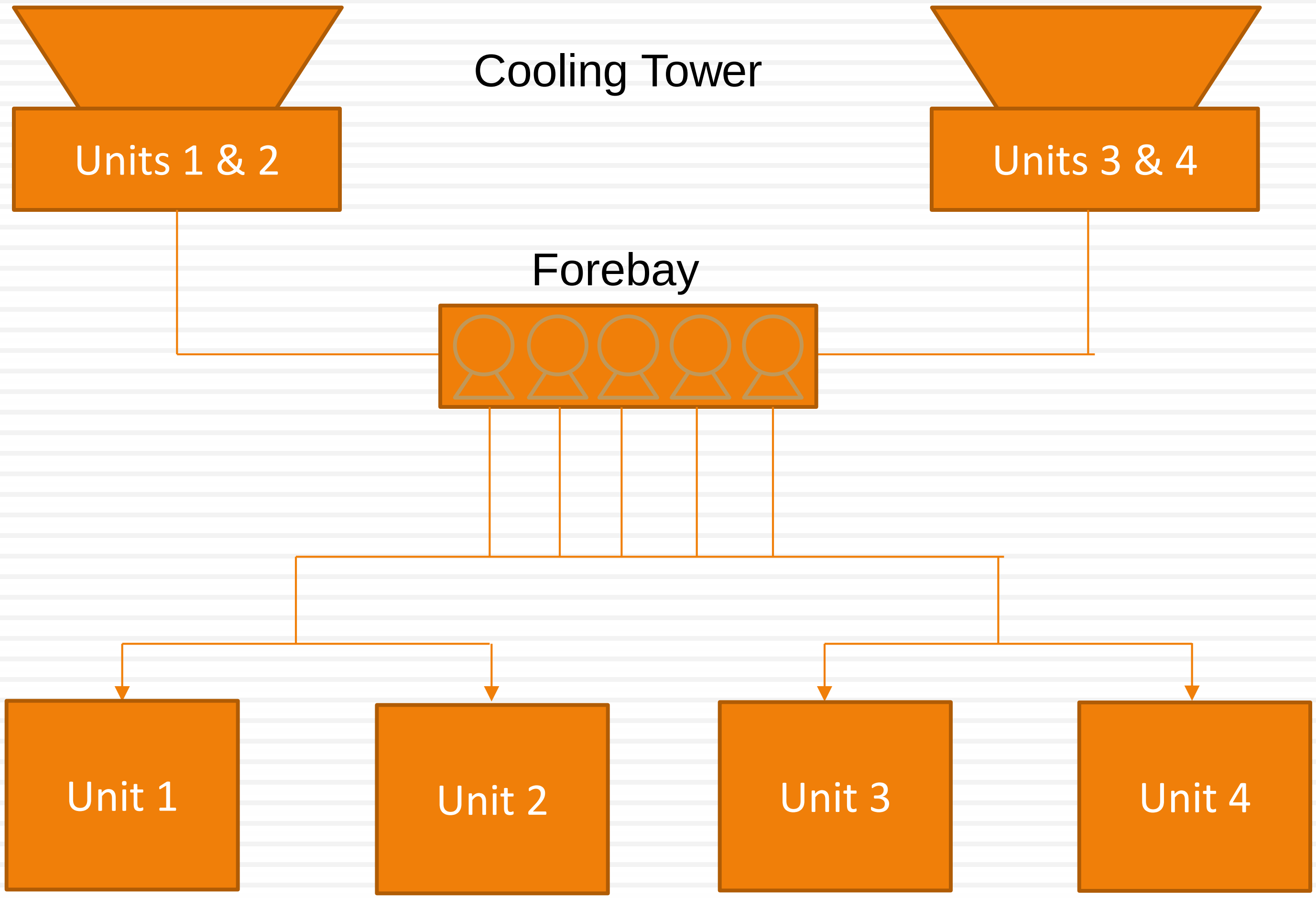
- Recommendation
  - Potential area to do CFD analysis and reduce pressure drop
  - At least 15 – 20 mmwc reduction in pressure drop possible
  - Successfully implemented in many cement plants & Utility power plants

Annual Saving	**-**	**Rs 4.0 Lakhs**
Investment	**-**	**Rs 5.0 Lakhs**
Payback period	**-**	**12 Months**

Optimizing operation of Cooling water pump

- Background
  - 4 x 135 MW IPP:
    - 4 Cooling water pumps for condenser cooling and auxiliary cooling water requirements
      - Common for all 4 units
  - Operating condition
    - CW operate at discharge pressure of 0.21-0.23 Mpa
    - Range across the condenser – 7.5 Deg C

Optimizing operation of Cooling water pump



Optimizing operation of Cooling water pump

- **Observation by the plant team**
  - The team observed that by increasing the range across condenser, the cooling water requirement could be met with 3 CWPs alone.
- **Action taken**
  - Initially the flow through one of the CWP was throttled and when the valve positon reached 70%, the pump was stopped

Optimizing operation of Cooling water pump

- **Existing System**
  - The 3 pumps operate with
    - Discharge pressure – 0.18 to 0.19 Mpa
  - Range across condenser
    - Increased from 7.5 to 9.5 Deg C
- **Benefits**
  - Reduction of power by stopping one pump
  - Loading of cooling tower reduced with reduction in total water flow quantity

Optimizing operation of Cooling water pump

- **Savings**
  - The overall savings achieved from this project by stopping one pump was
    - 2350 kw
  - Investment - NIL

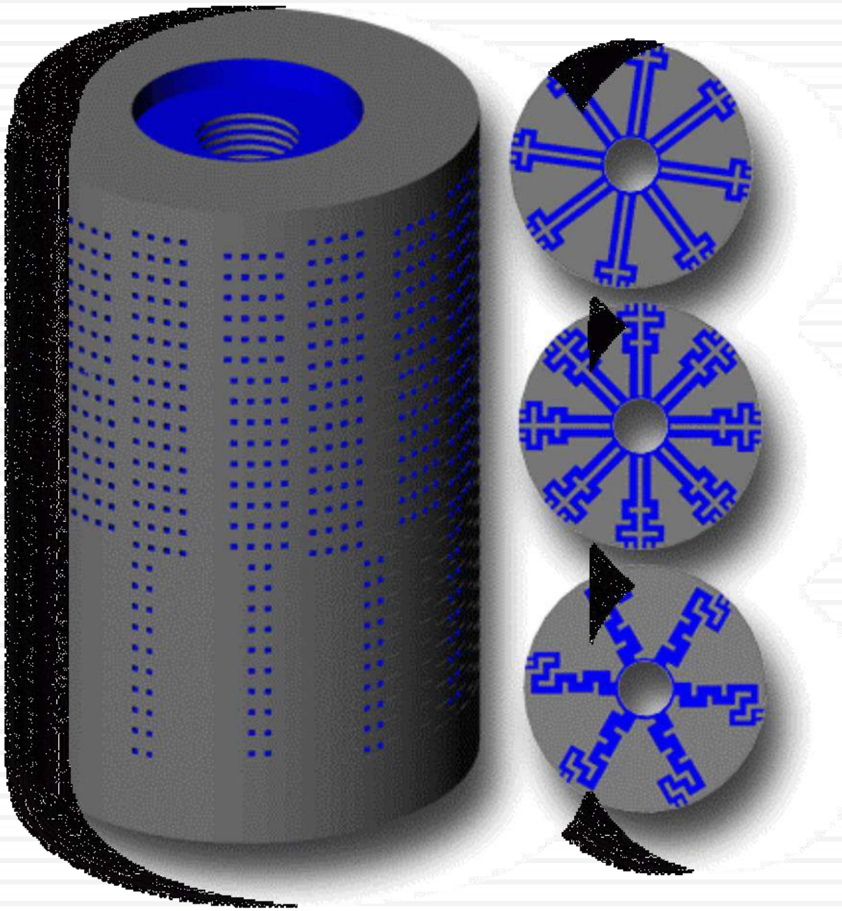
Installation of Multistage Pressure Reduction Drag Valve

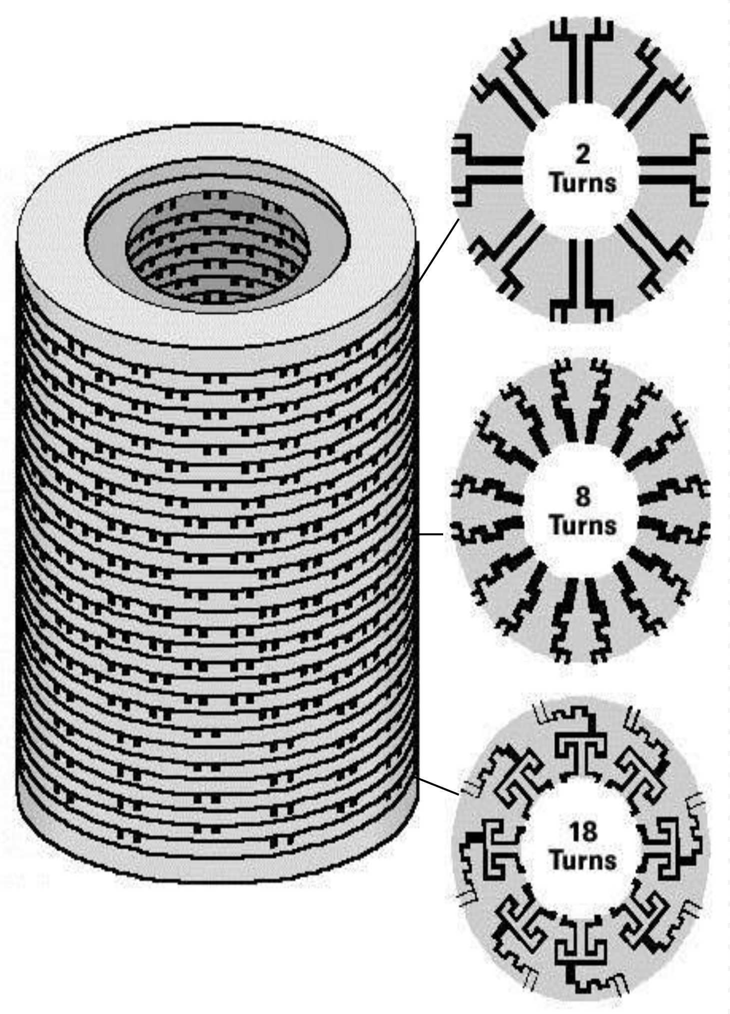
- Difference in drum flow and total pump flow
  - Passing of recirculation line
- Quantity of recirculation
  - BFP – 1 = 14 m^3/hr
  - % of passing : 7%
- Possible reason for passing of recirculation line
  - Higher dp across the valve
- Good potential exists by avoiding recirculation

CII

Installation of Multistage Pressure Reduction Drag Valve

Installation of Multistage Pressure Reduction Drag Valve





Installation of Multistage Pressure Reduction Drag Valve

- **Difference in drum flow and total pump flow**
  - Passing of recirculation line
- **Recommendation**
  - Replace the exist valves with multi stage pressure reduction drag valve
  - Reduces recirculation flow

Installation of Multistage Pressure Reduction Drag Valve

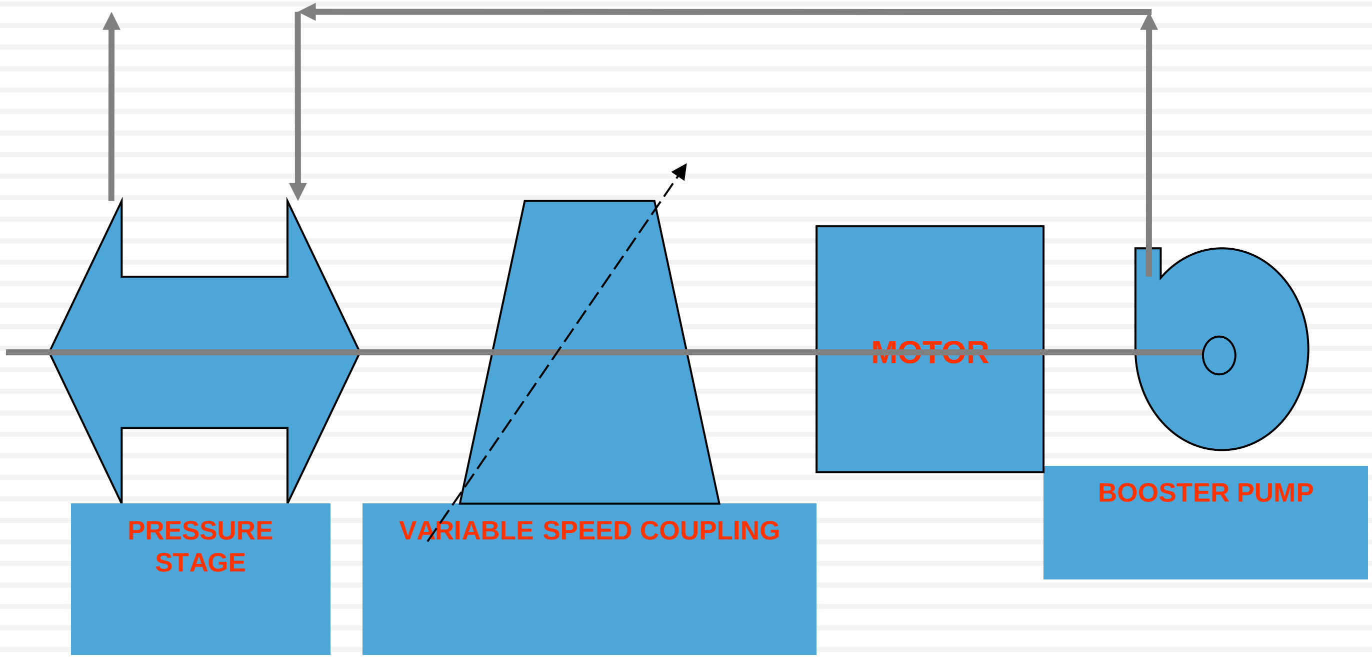
Annual Saving	-	Rs 30.00 Lakhs
Investment	-	Rs 45.00 Lakhs
Payback	-	18 Months

Speed Optimisation of unit -1 & 2 BFP hydraulic coupling

Unit-1 & 2 Boiler Feed Pump Specification

- 2 X 100 % per unit
- Single stage Booster pump, make Weir (UK)
- Three stage Pressure stage pump, make Weir (UK)
- Motor rating 8800 KW, make Peebles Electric Ltd (UK)
- Geared variable speed Turbo-coupling for Pressure stage pump, make Voith (Germany)

Speed Optimisation of unit -1 & 2 BFP hydraulic coupling



Speed Optimisation of unit -1 & 2 BFP hydraulic coupling

	Before Modification		After Modification	
	Design (47.5 Hz)	Operating (50 Hz)	Design (50 Hz)	Operating (50 Hz)
Input Motor Speed	1406 RPM	1470 RPM	1470 RPM	1470 RPM
Max Output Pump Speed	5730 RPM	5150 RPM	5350 RPM	5150 RPM
Gear Ratio	143/34	-	113/30	-
Total Loss in Coupling	1148 KW		430 KW	

Speed Optimisation of unit -1 & 2 BFP hydraulic coupling

- **Intangible benefits:**
  - Reduction of Hydraulic oil temperature by 30°C which in turn reduced the cooling water demand for the pump

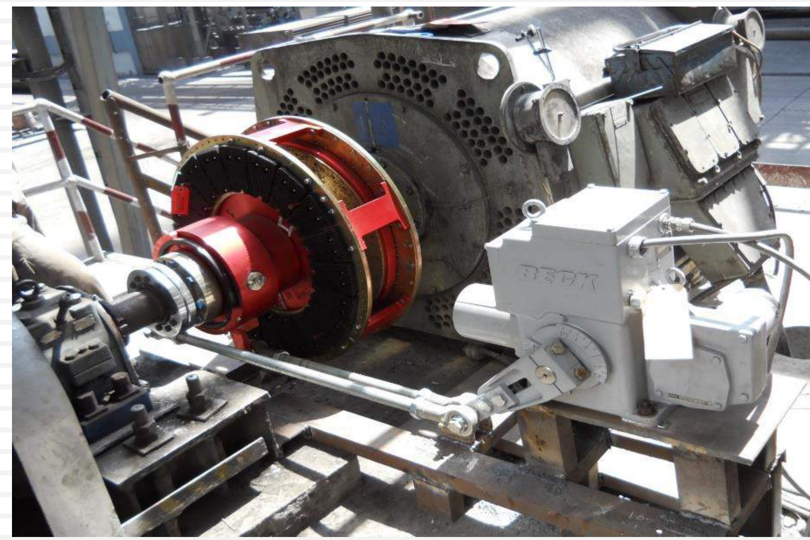
Annual Saving	**-**	**Rs. 140 Lakhs**
Investment	**-**	**Rs. 80 Lakhs**
Payback period	**-**	**7 Months**

Installation of Magna Drive

- **Magnetic coupling**
  - **Principle of operation**
    - **It has a magnetic rotor surrounded by a conductor rotor.**
    - **Both the rotors are never in contact with each other**
    - **Torque is transmitted through an air gap in the coupling by the relative motion between the conductor rotor and extremely powerful permanent magnets contained in the magnetic rotor.**
    - **This relative motion creates a magnetic field in the conductor thereby transmitting torque**

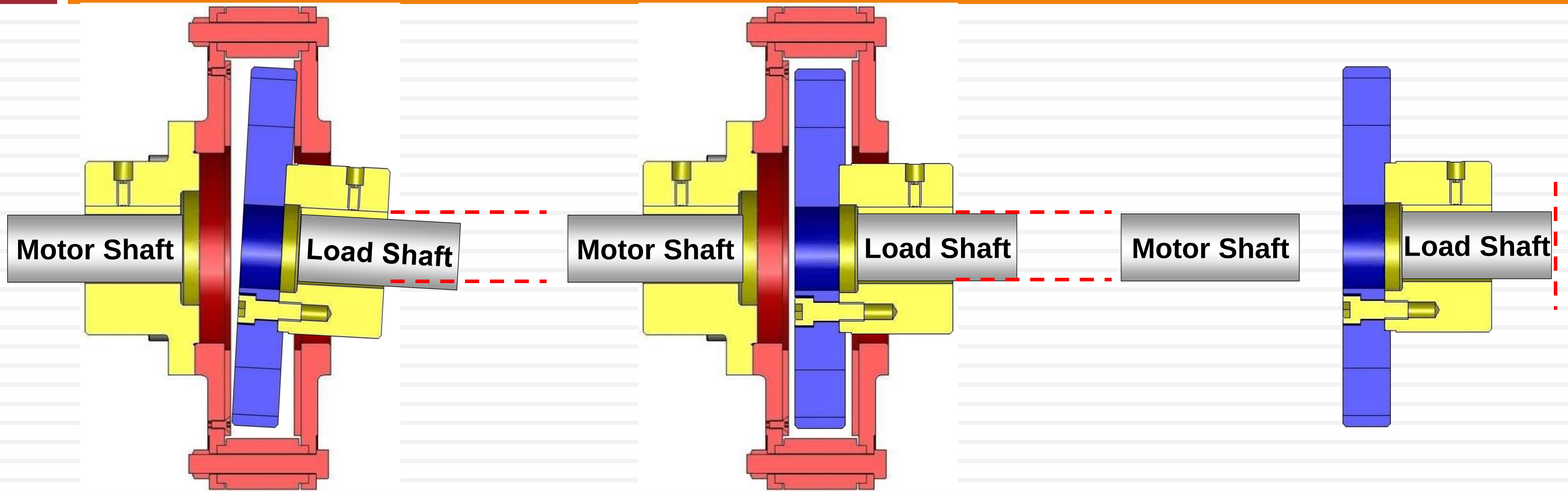
Installation of Magna Drive

- **Magnetic coupling:**
  - Advantages
    - The signal could be given directly from the DCS (4-20 mA)
    - No direct coupling hence lesser stress on the motor
    - No harmonics
    - No separate unit/ space required unlike VFD panel
    - Tolerates misalignment, thermal expansion and vibration issues
    - Operates with any kind of motor
    - Slip of 2-3%

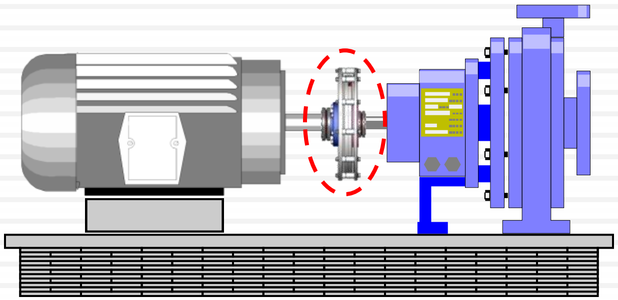


Magnetic Adjustable Speed Drive for 190 KW ID Fan

Installation of Magna Drive



Can operate with <u>Angular Misalignment</u>	Can operate with <u>Parallel Misalignment</u>	Can operate with <u>Axial Misalignment</u>

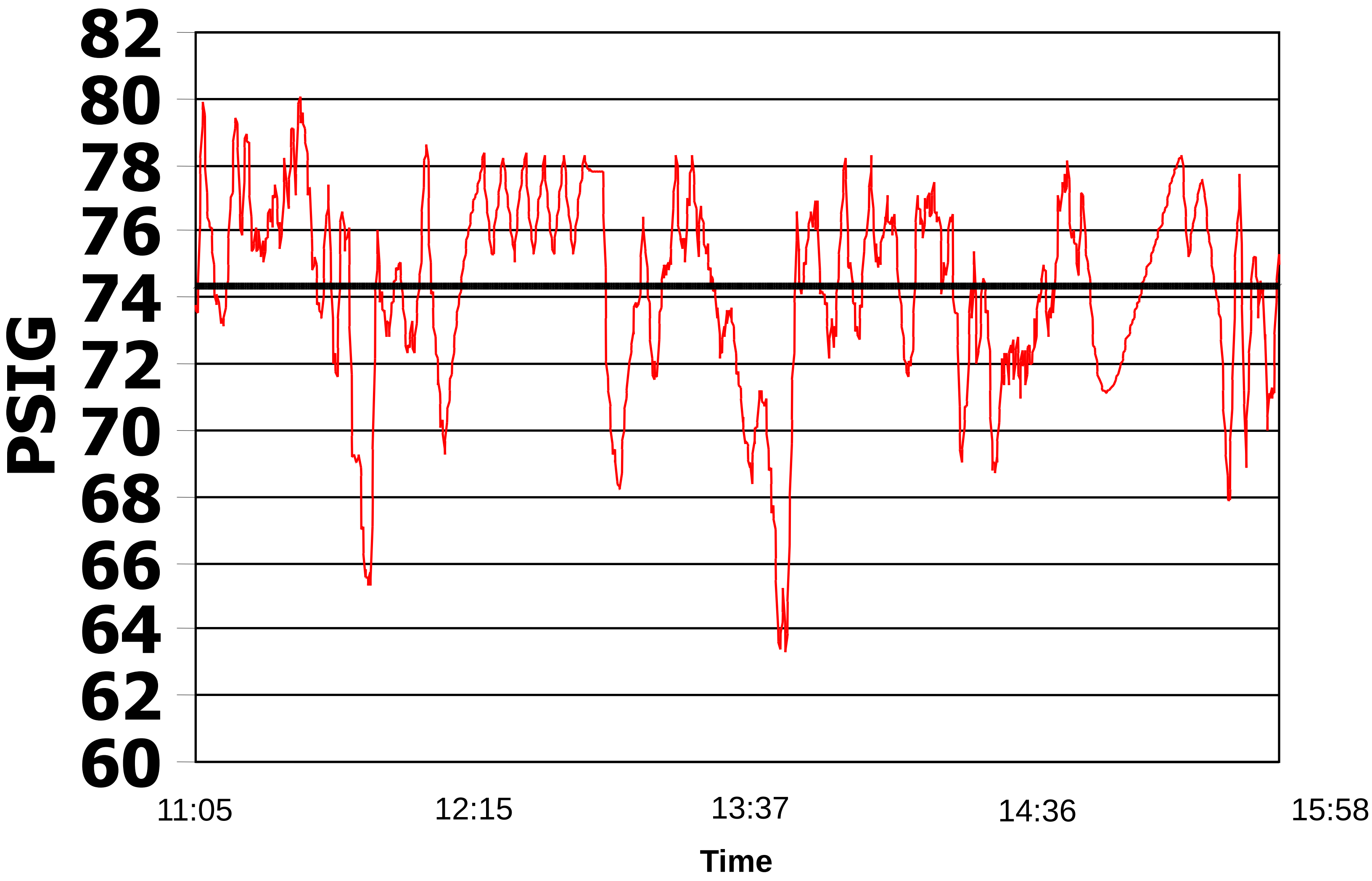


CII

Install Intermediate controller in compressed air system

- Reciprocating compressors 3 no's in operation for compressed air supply
  - Instrumentation & Service air supply
  - Total Capacity : 1250 cfm
- Operating pressure variation significant
  - Load pressure : 6.0 kg/cm^2
  - Unload pressure : 7.0 kg/cm^2
- Total compressor load : 450 kW

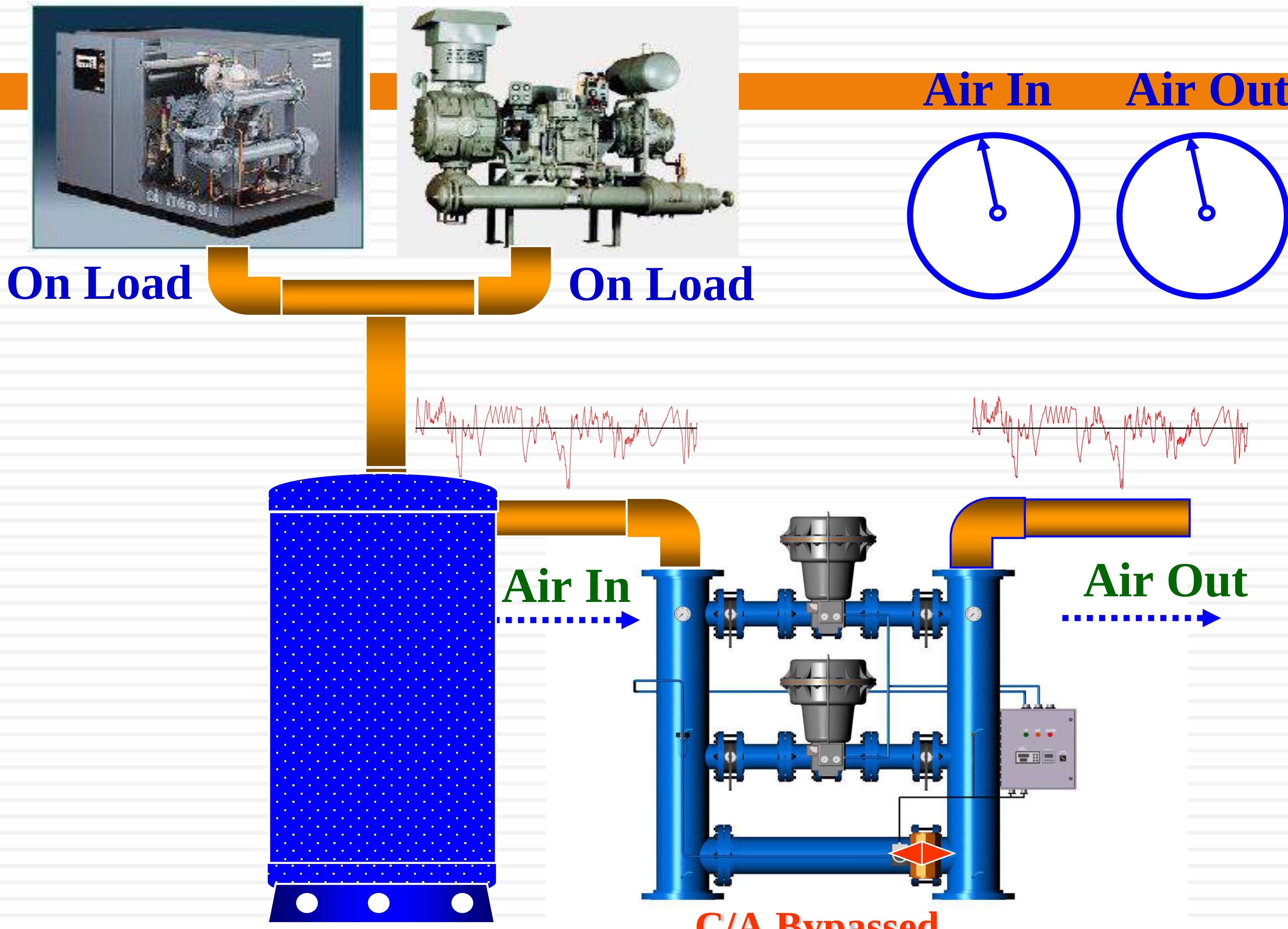
Typical Compressed Air Pressure Real Time Data

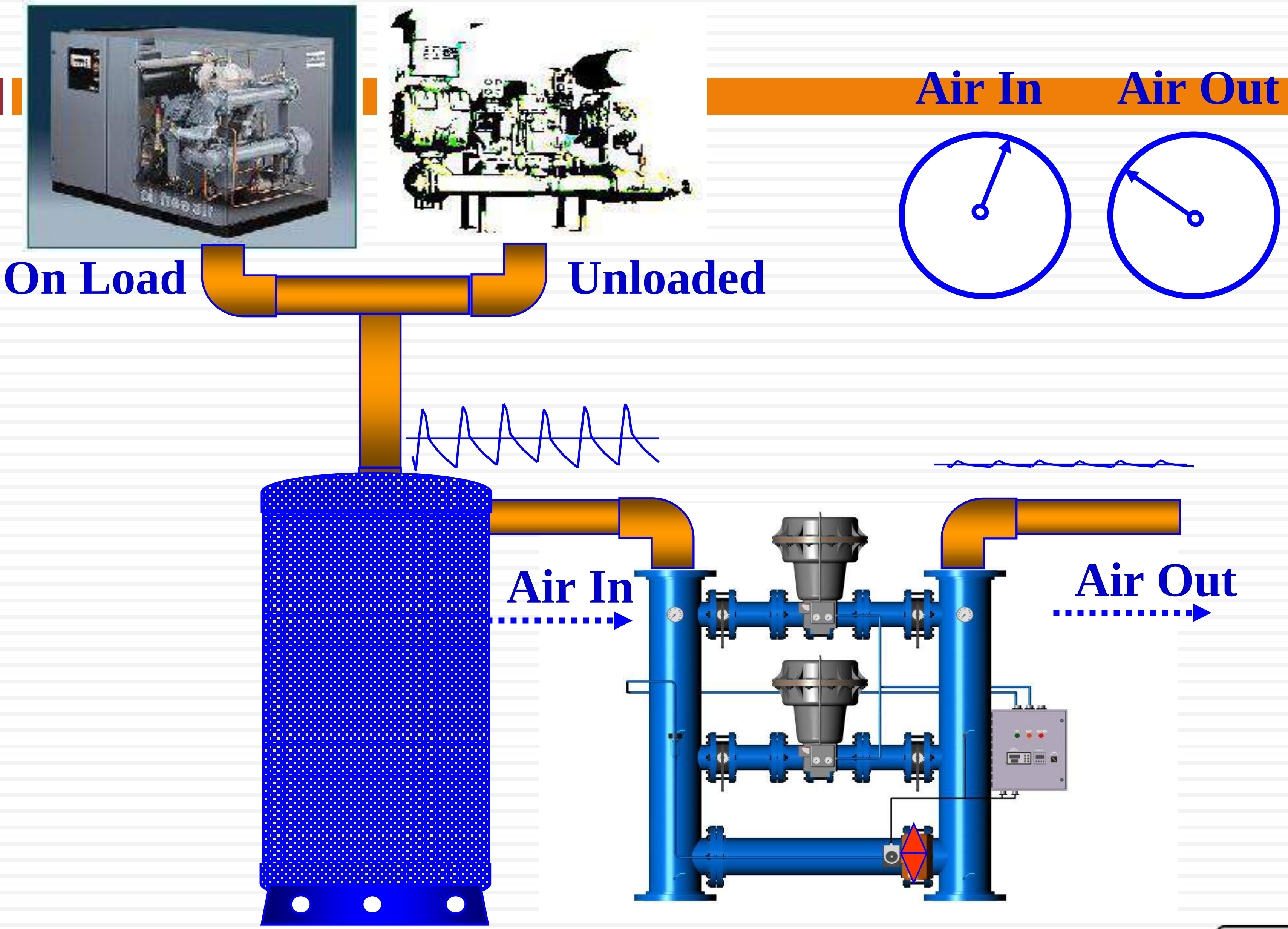


Effect of pressure fluctuation due to artificial demand

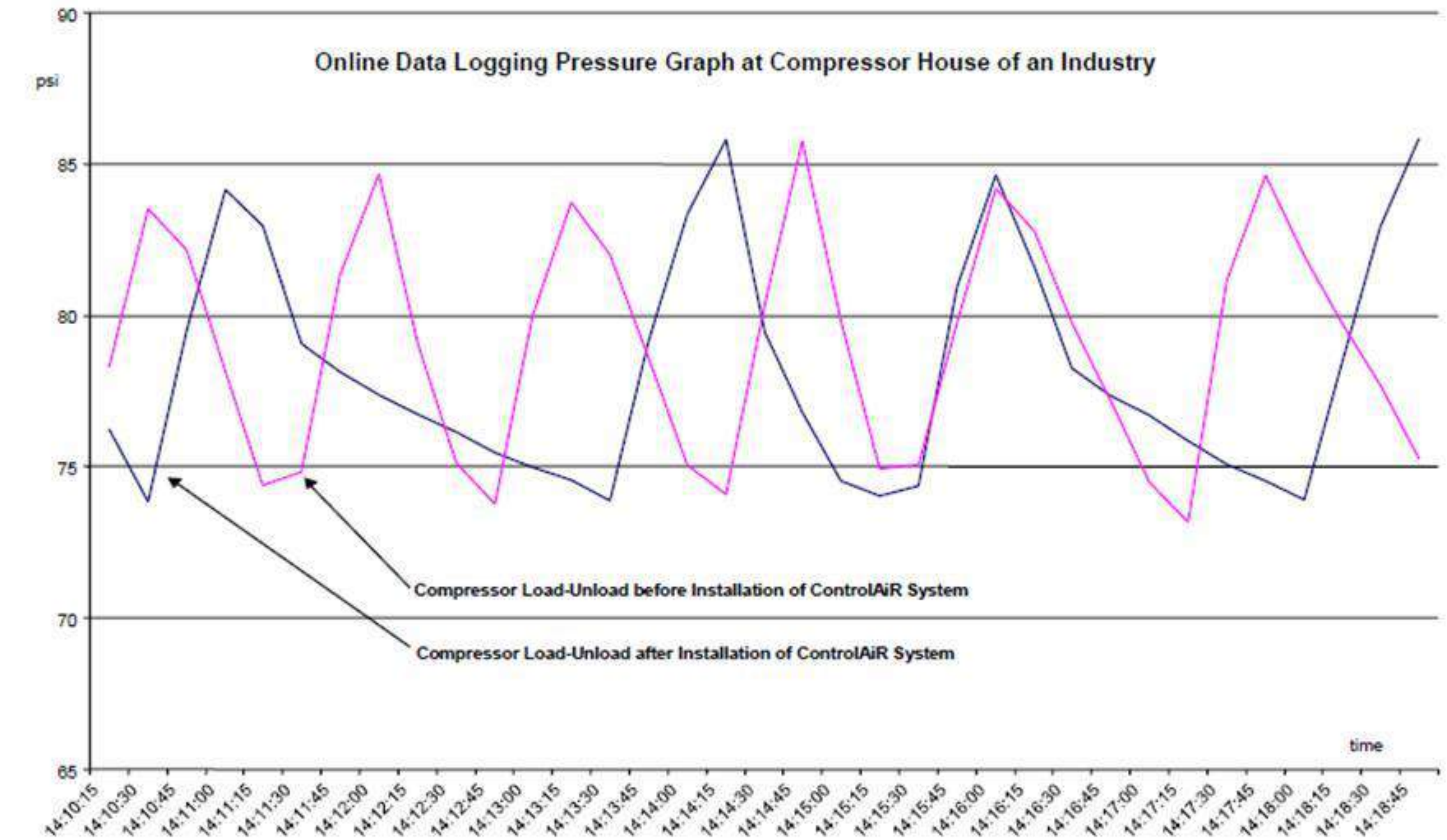
- Artificial demand : compressor tries to maintain higher set pressure in the entire system
- Consumption increases at
  - User equipment
  - Open end users such as cleaning
  - Increase in leakage
- Increased compressor power consumption

CII


Air In
Air Out
On Load
On Load
Air In
Air Out
C/A Bypassed


Air In
Air Out
On Load
Unloaded
Air In
Air Out

Pressure graph with & without controller



Benefits of Installing Controller

- Energy savings from 7 – 20%
- Reduction in air generating pressure
- Constant air pressure
  - +/- 0.1 kg/cm^2
- Reduction in artificial demand
- Reduction in compressed air leakages

Annual Saving	**-**	**Rs. 15.75 Lakhs**
Investment	**-**	**Rs. 15.00 Lakhs**
Payback period	**-**	**13 Months**

CII

Further Energy conservation measures

Energy conservation measures

- Installation of Combustion Optimisation system
- Variable frequency drive (VFD) for - BFP, CEP, CWP, ACWP, DM transfer pumps, FD, PA/ SA Fan & ID fan etc..
- Monitor the efficiency of the boiler
- Monitor the flue gas exit temperature
- Calculate the heat loss from the hot surface
- Transfer makeup water from CST to condenser hot-well with the help of gravity

CII

To Sum up…

- Tremendous potential to reduce the present operating heat rate
- Become a World Class Energy Efficient unit
  - Implement the latest technologies
  - Learning the best practices from the other sector / industries

Thank you

K V Kiran Kumar
Counsellor
Confederation of Indian Industry
CII - Godrej Green Business Centre, India

Dir: +91 40 44 185 137
Mobile: +91 9849970404
Fax: +91 40 23 112 837
E-mail: kirankumar.kv@cii.in
www.greenbusinesscentre.com / www.cii.in