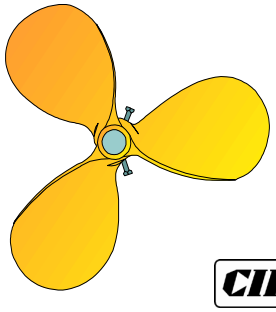
Fans & Blowers

CII

Fans & Blowers

- **Simple Definition**
  - **Machines to move gases (or) gases mixed with small solid particles**
- **Operation of fans & pumps similar**
- **Broad Classification**
  - **Centrifugal**
  - **Axial**



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Fans & Blowers

- Major energy consumer in a Cement plant next only to grinding
- Tremendous potential for saving
- Indian Cement industry has been continuously working on this
  - Everyday newer opportunities emerging

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Difference Between Fans, Blowers and Compressors

As per ASME Definition ...

Equipment	Specific Pressure*	Pressure rise (mm WG)
Fans	< 1.11	1136
Blowers	1.11 to 1.20	1136 – 2066
Compressors	> 1.20	-

* Ratio of discharge pressure to suction pressure

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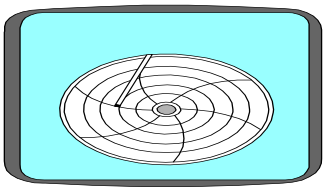
Energy Savings Potential

Fans & Blowers - Major Energy Consumer

- **Cement**
- **Paper**
- **Power Plants**
- **Sugar**



Energy Consumption - 10 to 25%
Depending on Type of Industry

Energy Saving Potential – About 25%

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Fans & Blowers - Formulae

- **Capacity** α **(RPM)**
- **Head** α $(RPM)^2$
- **Power** α **(Capacity x Head)**

  α $(RPM)^3$

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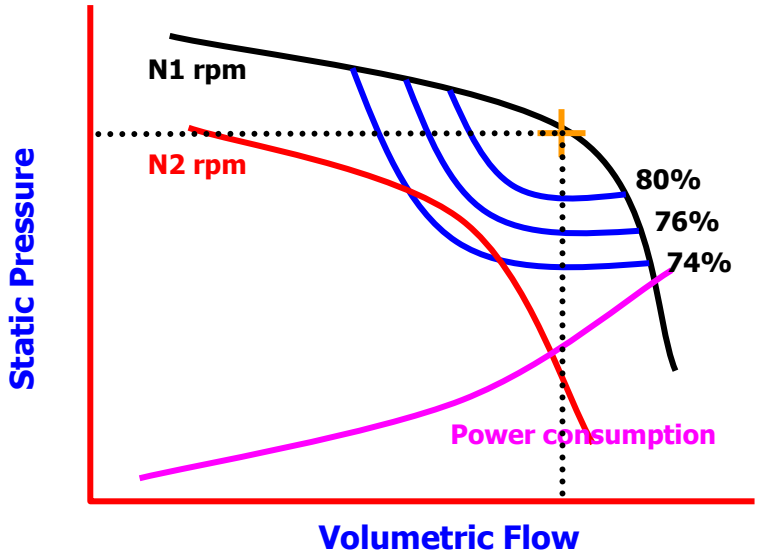
Fans & Blowers Formulae

If the RPM is reduced by say 10%, what will happen to the

- **Capacity : reduce by 10%**
- **Head : reduce by 19%**
- **Power : reduce by 27%**

Characteristic Curve of Fan



Fan Efficiency

$$\eta_{fan} = \frac{Q\ (m^3/s) \times \Delta P\ (mm\ WC)}{102 \times \eta_{motor} \times kW\ (I)}$$

Where,

Q = Volumetric Flow

ΔP = Static Head Developed by fan

Typical Efficiencies – 40 to 70%

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Factors Affecting Fan Performance

- RPM
- Diameter
- Density
- Temperature

		RPM	Diameter	Density	Temperature
Volumetric capacity	α	n	D^3	-	-
Pressure rise	α	n^2	D^2	ρ	1/T
Power consumption	α	n^3	D^5	ρ	1/T

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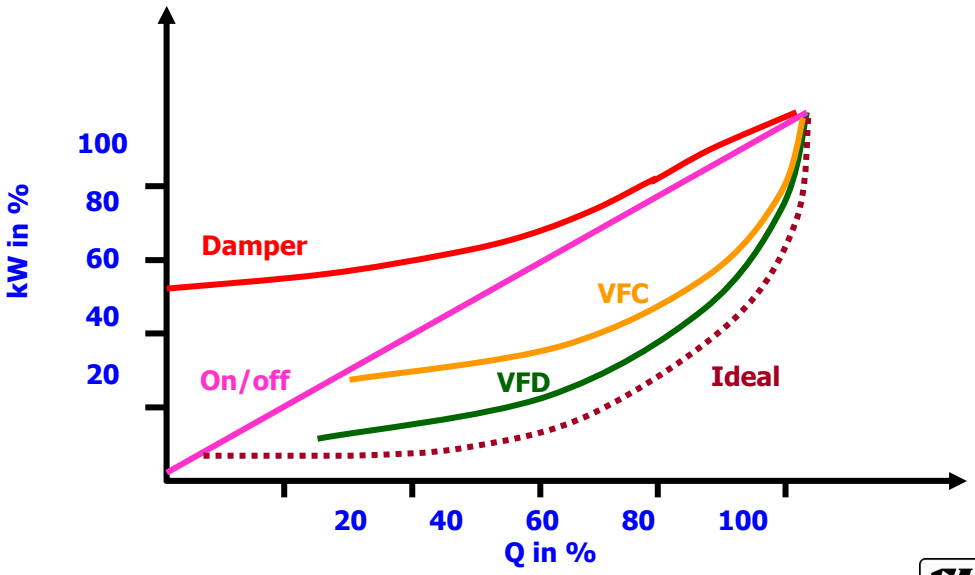
Effect of Various Capacity Controls



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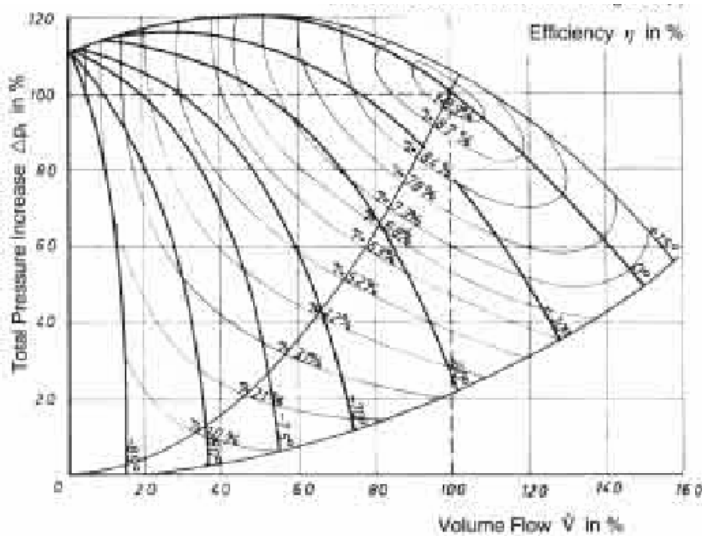
Inlet Guide-vane control



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Inlet Guide-vane control

- Different from damper
- Guide-vane gives a twist to the air in the direction of rotation
  - Different characteristic curve
  - Useful for marginal capacity reductions
- Useful earlier
  - VFDs were not cost economic
  - VFD reliability was a question

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Throttling of a Fan

- Suction/Delivery
- Why?

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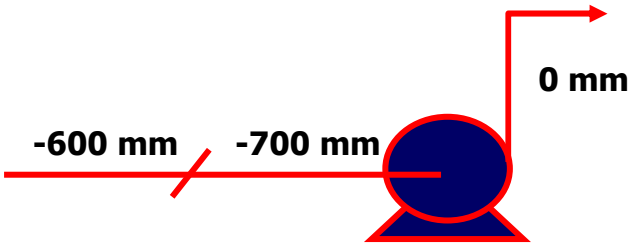
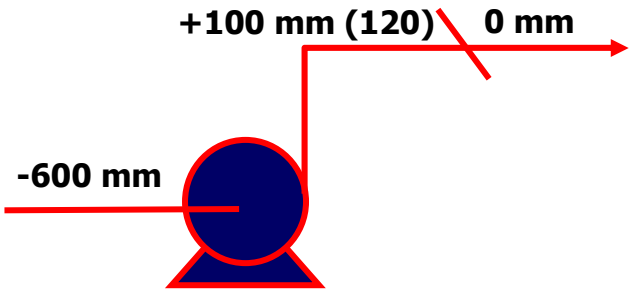
Throttling - Suction



Average pressure of fan = $\frac{(10336 - 700) + (10336 - 0)}{2}$

= 9986 mm WG

Throttling - Delivery



Average pressure of fan = $\frac{(10336 - 600) + (10336 + 100)}{2}$

= 10086 mm WG

Average density higher, power consumption higher

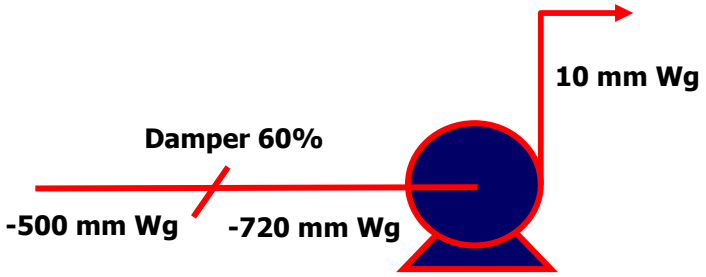
Power Consumption - Oversized Fan

Fan designed

- 1,20,000 m^3/h
- 650 mm Wg

Actual requirement

- 90,000 m^3/h
- 510 mm Wg



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Potential in Oversized Fan

Energy saving potential in over sized fan

$$= \frac{\Delta P \text{ across damper}}{\text{Total pressure rise}} \times \text{Power Cons.}$$

= [(720 – 500)/(10 – (-720)] x 289 kW

= (220/730) x 289 kW

= 87 kW

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Energy Audit in Fans & Blowers in a Cement plant

- Is it off the correct capacity/head?
- How is the fan controlled?
  - Damper throttling
  - Guide vane control
  - Speed control – GRR / SPRS / VFD

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Energy Audit in Fans & Blowers in a Cement plant

- Can the capacity/head be further fine tuned?
- What is the efficiency of fan?
- Can it be replaced by high η fan
- Is it possible to reduce system resistance – Suction / discharge side ?
- Can fan operation be interlocked with process operation?

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Can fan be replaced by one of lower capacity / head ?

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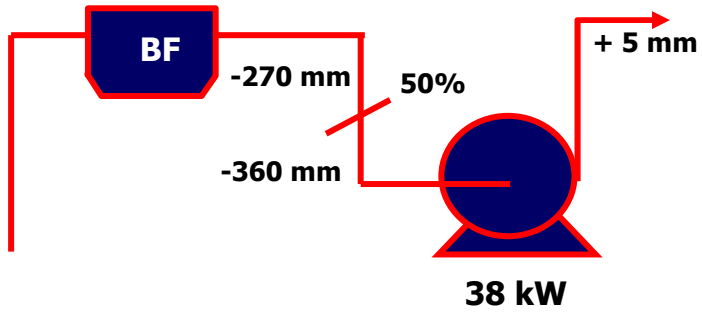
Coal Mill Ventilation Fan Speed Reduction



- **Pressure drop** = (90/365) X 100
  = 24%
- **Head required** = 0.76 times present head

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Coal Mill Ventilation Fan Speed Reduction

- Fan had belt drive
- RPM of fan reduced by 10%

Annual Savings	= Rs. 1.34 Lakhs
Investment	= Rs.0.05 Lakhs
Payback period	= 1 month

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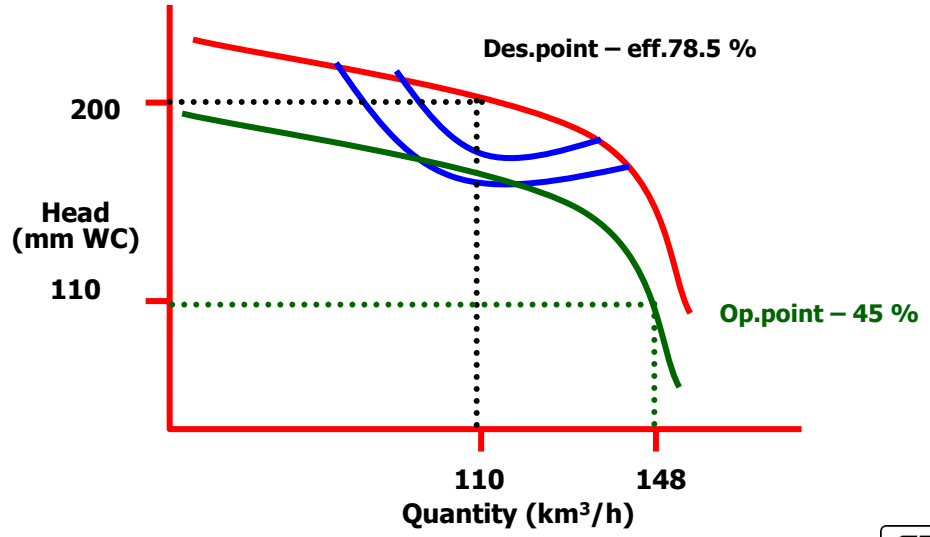
ESP Exhaust fan

- Fan Designed for 300 TPD Kiln output
- Fan Rating
  - 1,10,000 m3/h, 200 mm WC, 110 kW
- Fan Operating With DC drive
- Present Operation – 450 TPD kiln output
- Actual fan parameters
  - 1,48,000 m3/h, 110 mm WC, 90 kW

CII

ESP Exhaust fan



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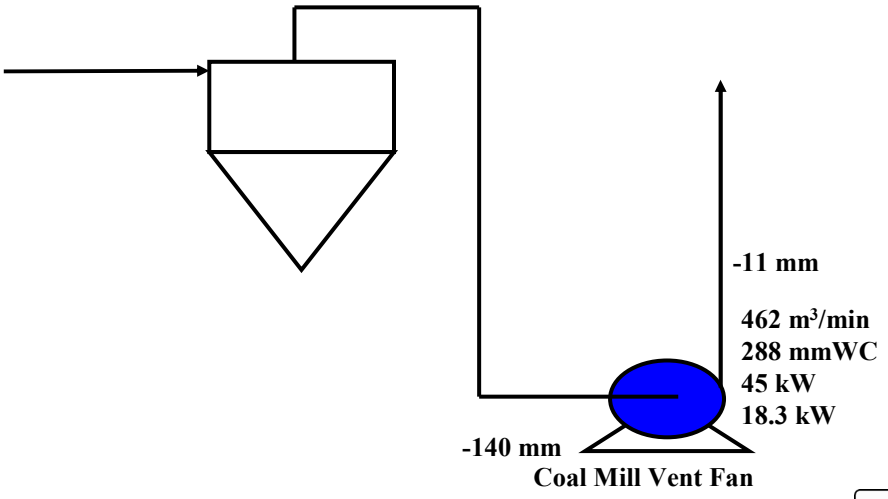
Install New Correct Head Fan for ESP Exhaust

- Fan Rated for 78.5% Efficiency
  - Present Efficiency - Only 45%
- Replaced fan with new correct head fan – 150000 m³/hour, 120 mm

Annual Savings	= Rs.12.00 Lakhs
Investment	= Rs.10.00 Lakhs
Payback period	= 10 months

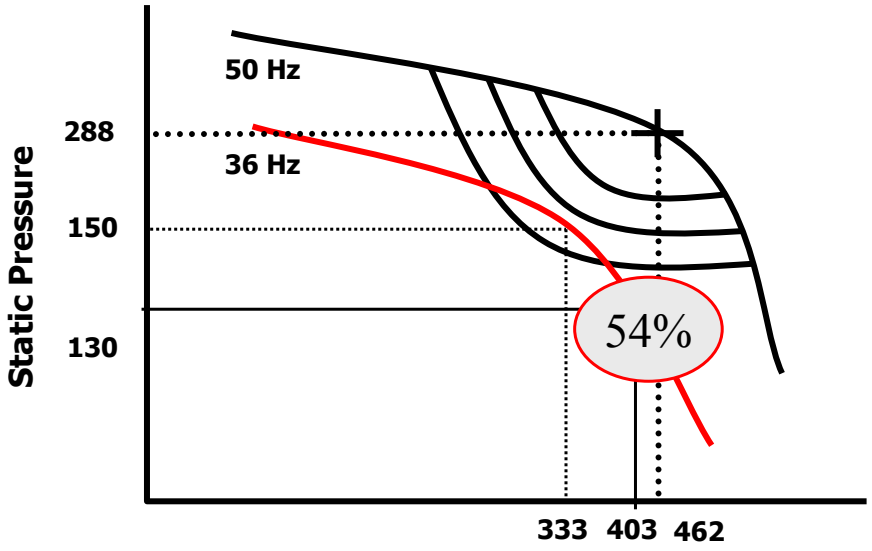
CII

COAL MILL VENT FAN - 2



CII

Fan Characteristic Curve



CII

Install Correct size Fan for Coal Mill Vent Fan - 2

- Fan Efficiency - 54%
- Install a correct size higher efficient fan
  - At least 70% efficiency
- Total savings - 7.4 kW

CII

Install Correct size Fan for Coal Mill Vent Fan - 2

- Annual Savings : Rs. 0.92 Lakhs
- Investment : Rs. 1.00 Lakh
- Payback : 13 months

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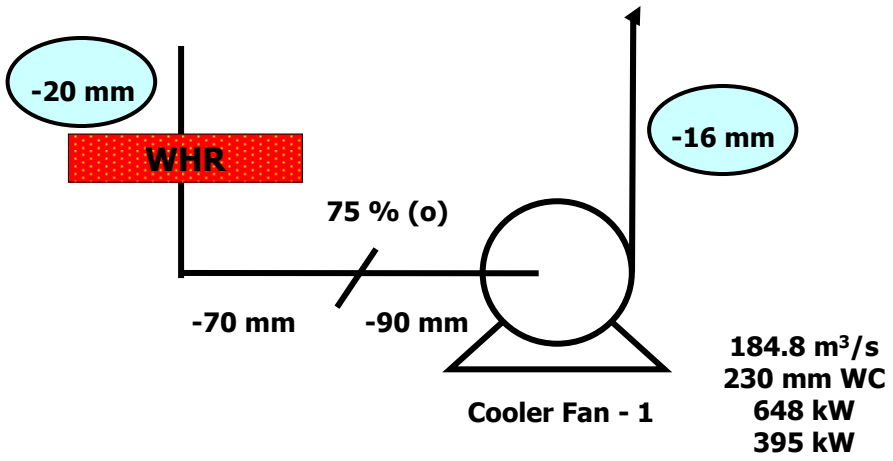
Install New Cooler Vent Fan with higher efficiency



CII

Install New Cooler Vent Fan with higher efficiency

- Cooler Vent Fan – 395 kW
  - Speed Controlled
  - Damper Throttled
- Power Consumption – Break up
  - WHR System – 65% : 265 kW
  - Damper Loss – 27% : 106 kW
  - Actual Output – 8% : 22 kW
- Low operating efficiency – 15.23%

CII

Install New Cooler Vent Fan with higher efficiency

- Recommend to
  - Install correct size fan with VFD
    - ✓100 m^3/s, 90 mm WC, 150 kW
    - ✓Power Consumption – 85 kW
  - Existing fan – Standby
- Good energy saving potential

CII

Install New Cooler Vent Fan with higher efficiency

Annual Savings	:	Rs. 59.0 Lakhs
Investment	:	Rs. 30.0 Lakhs
Payback	:	7 Months

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Suction side pressure drop

- Extensive discussions held
  - Fan suppliers BHEL & ABB
  - Fan experts
- Suction pressure drop
  - Not more than 15-20mm
- Cooler fans invariably very high - 70-90 mm
  - Intentional

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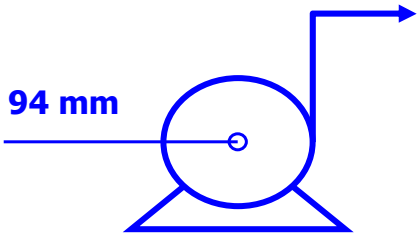
Fan inlet pressure drop

Cooler fan - 10

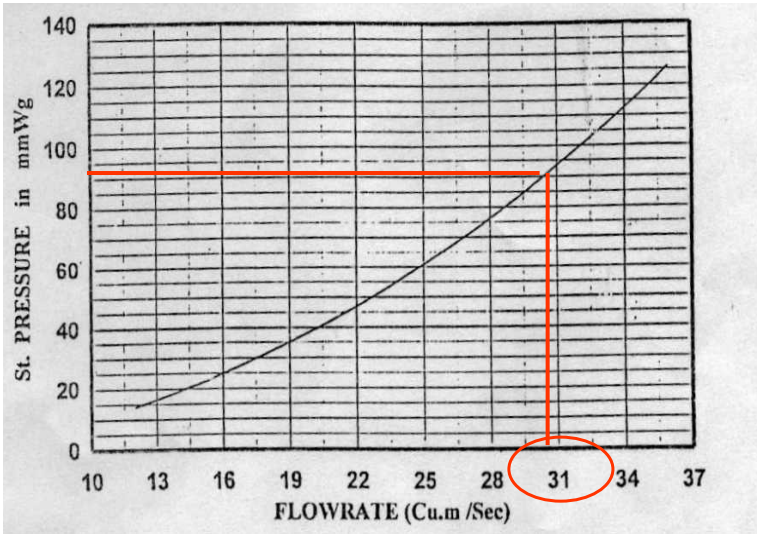
- 94 mm



- Total Pr Rise of Fan - 558 mm WC
- Inlet pressure loss - 16.8% of pr developed
- Power consumption - 210.2 kW

CII

Piezo Ring Characteristic Curve



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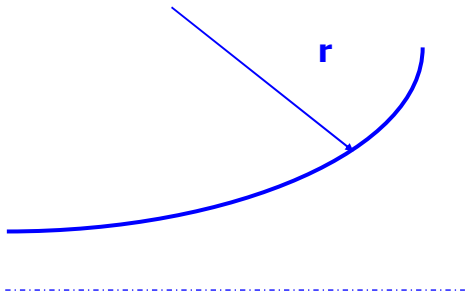
Suction side pressure drop

- Typically flow measurement
  - using Piezometer ring
  - Additional pressure difference for accuracy
- Measures to be taken
  - Reduce inlet pressure drop
  - Measure air flow
- For reducing the inlet pressure drop
  - Inlet Air velocity - 10-12 m/sec
  - Reduction in entry loss – using bell mouth

CII

Modification of suction side



- Radius of bell mouth
  - 0.25 x effective diameter
- Flow measurements using aerofoil

Flow measurement

- Aerofoil in cooler fans
  - Initial apprehension – dust
  - Prone for wear due to dust
- Extensively practiced in power plants FD fans
- Inlet Pressure – not more than 20 mm WC
- Saving potential - 6-7%

Flow Measurement - Alternate

- Majority fitted with VFDs
- After inlet modification
  - Speed & discharge pr. thro a software to determine the flow

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Lower inlet suction 'pressure drop' in identified fans

Annual savings	-	Rs 8.58 Lakhs
Investment	-	Rs 2.0 Lakhs
Payback period	-	3 Months

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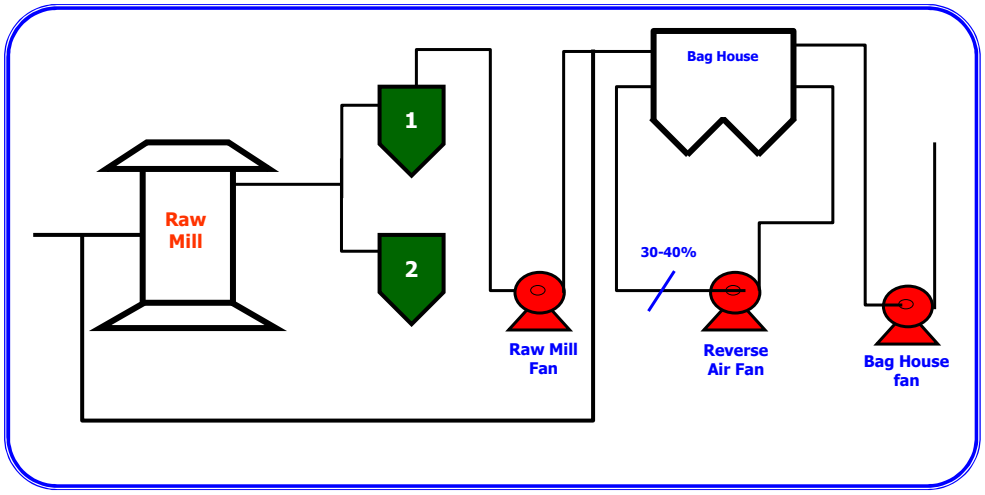
Optimize power consumption of Bag House Fan



CII

Optimize operation of Reverse air fan

- Reverse air fan-Removal of Bag house dust
- Operation of RA fan- 'ON_OFF' control – Good step
- RA Fan Control studied
  - Fan – Damper controlled
  - Requirement – intermittent

CII

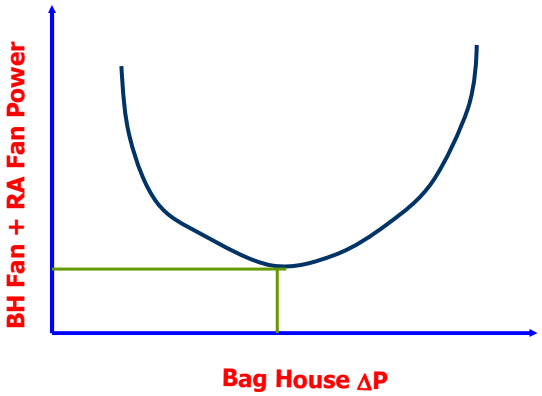
Variation of BH Fan Power

- Analysis of Readings
  - Bag house '∆P' - 94 mm – 142 mm
  - Significant variation in BH Fan power consumption
    - ✓ Variation – 650 kW to 1175 kW

Optimization of BH Fan Power

- Approach
  - Increase of RA fan quantity
    - ✓ Reduction in '∆P' of BH
    - ✓ Reduction in BH fan-power consumption
  - Optimization – After installing VFD for RA fan
    - ✓ Operate RA fan in closed loop with BH '∆P' Diff. Pres. Settings – 90, 100, 110, 120, 130,140 mm, etc.
    - ✓ Monitor – BH fan + RA fan power

Optimization of BH Fan Power



Fix the RA fan 'ΔP' setting accordingly

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Optimization of BH Fan Power

Annual savings	**- Rs 21.42 Lakhs**
Investment	**- Rs 10.0 Lakhs**
Payback period	**- 6 Months**

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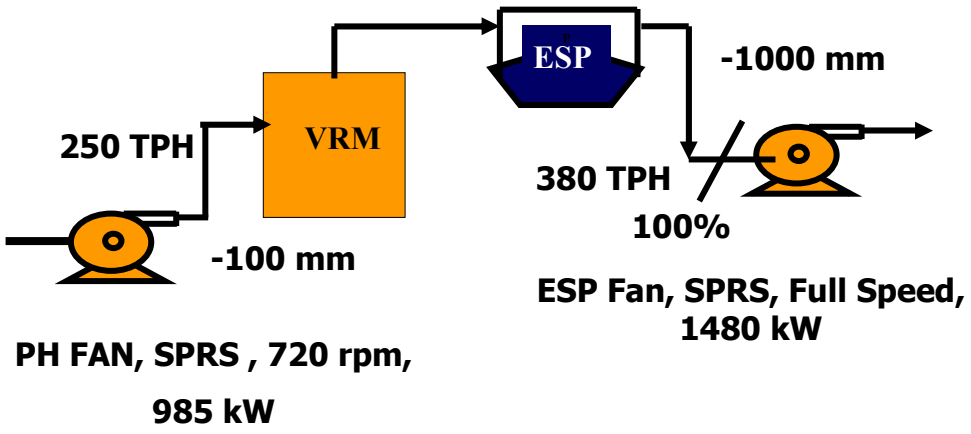
Optimise Operation of PH Fan & ESP Fan



CII

Optimise Operation of PH Fan & ESP Fan

- How to save energy in fans
  - Air infiltration – 128 TPH (60%)
- Reduce air infiltration by reducing system draught
- Action
  - Red. ESP fan speed - maintain (-) 20 mm at mill inlet
  - Inc P.H fan speed - meet P.H requirement

CII

Optimise Operation of PH Fan & ESP Fan

❖ **Power consumption**

P.H. Fan	ESP. Fan	Total
985 KW	1480 kW	2465 kW
1140 kW	1220 kW	2360 kW

❖**Annual savings - Rs 17.1 Lakhs**

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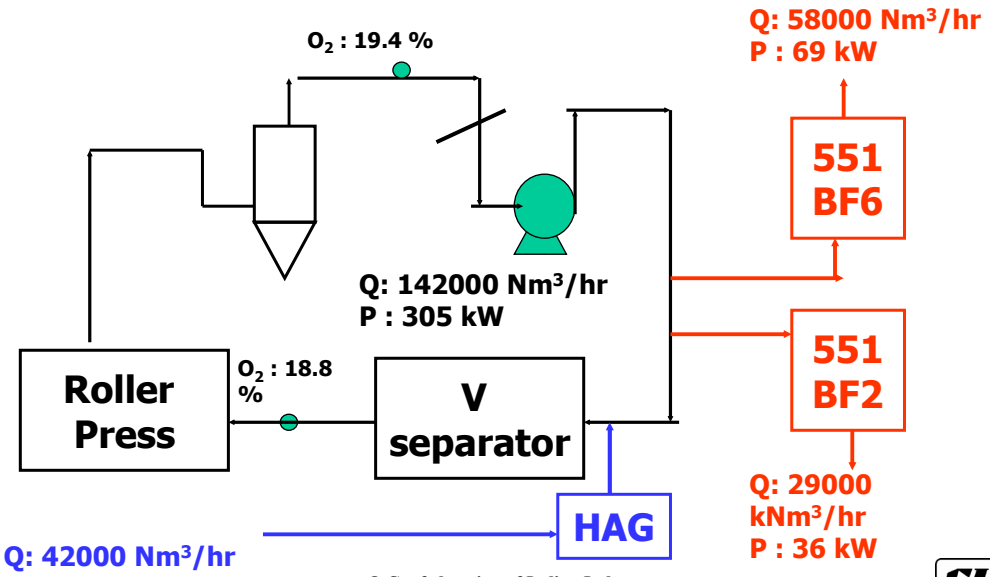
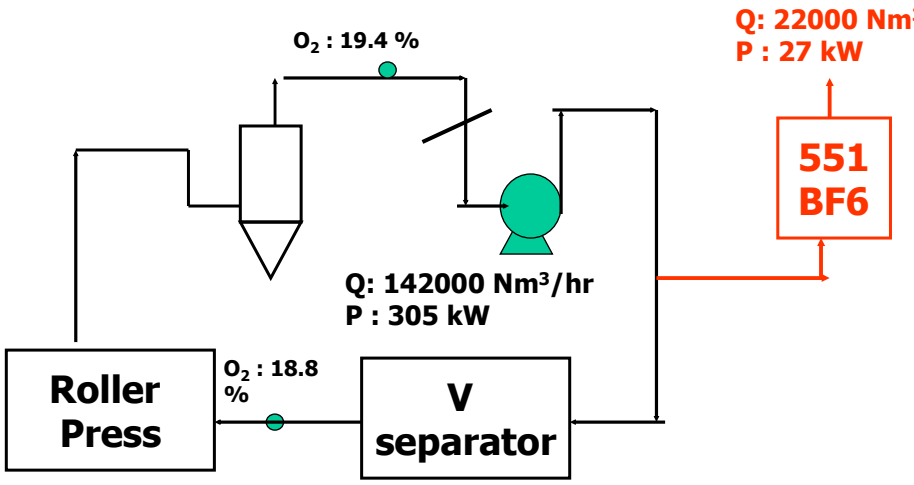
Optimise Ventilation air in slag circuit



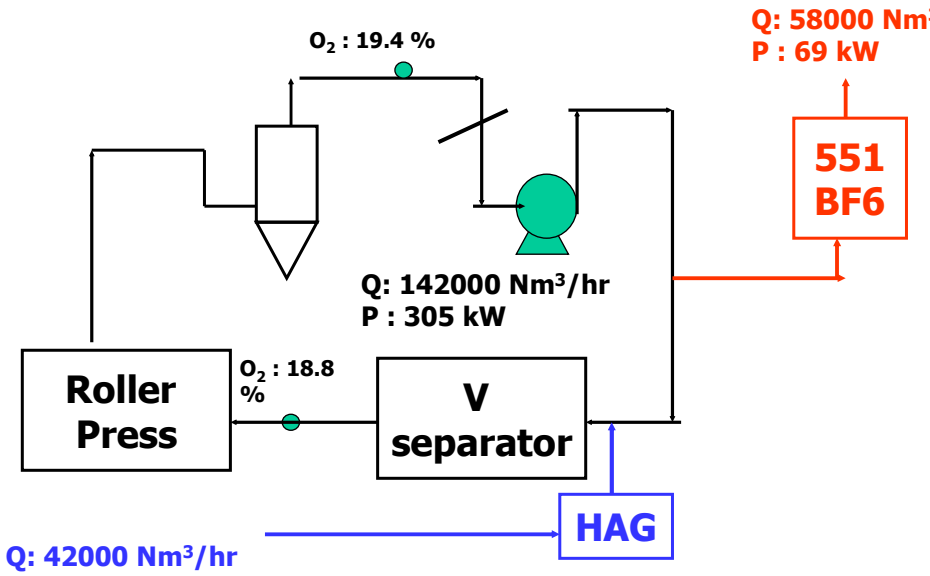
CII

Optimise Ventilation air in slag circuit



CII

Optimise Ventilation air in slag circuit



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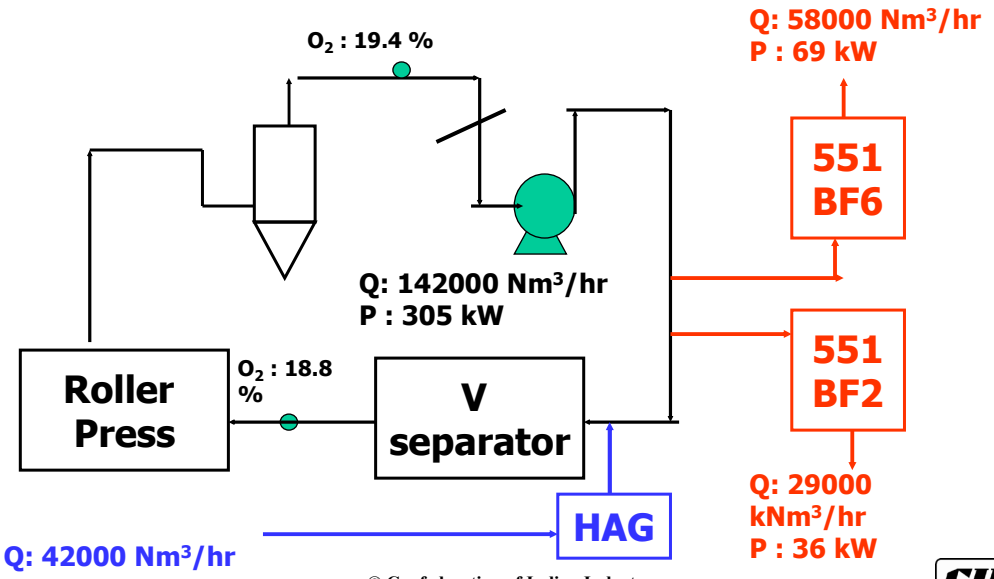
Optimise Ventilation air in slag circuit



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Optimise Ventilation air in slag circuit

- **False air by Air balancing method**
  - **>20000 Nm³ /hr**
- **False air arresting**
  - **Continuous activity**
  - **not only increases volume but can affect sep performance by turbulence, recirculation, pressure drop**

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Optimise Ventilation air in slag circuit

Annual Saving	**-**	**Rs 2.7 Lakhs**
Investment	**-**	**Rs 1.0 Lakhs**
Payback	**-**	**4 months**

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Natural Draught

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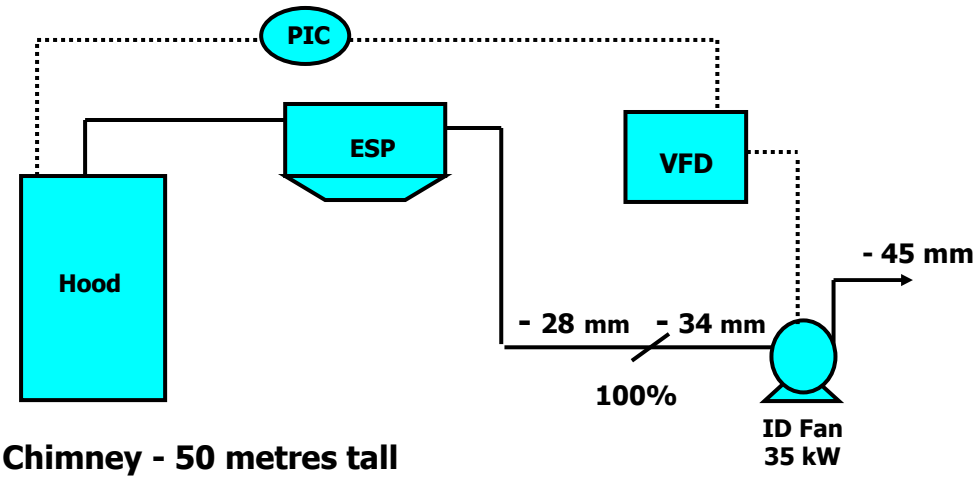
Impact of Natural Draught – 1.2 Mtpd plant



Chimney - 50 metres tall

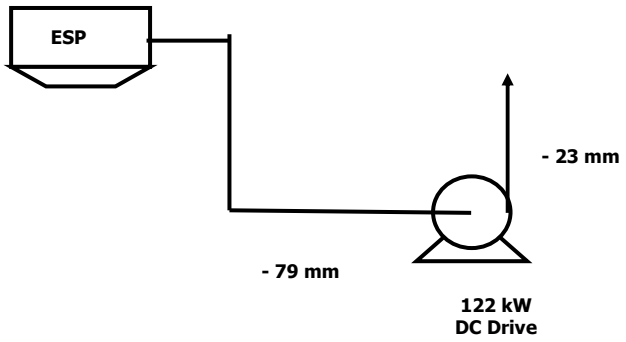
Natural draught > requirement

Cooler Vent Fan

- **In a 1.2 Mtpd plant**
  - **>50 m Chimney, 250°C exh temp**
  - **0.2 units / ton of clinker!**

Natural Draught – Very Important

Cooler exhaust fan in a Cement plant



Specific power – 0.67 units/ton

Increase Stack Height of Cooler exhaust

- **When cooler upgradation**
  - **Exhaust height to be increased**
  - **From 23 m to 60 m**
  - **Additional draft - 65 mm**
    - ✓ **Net benefit - 50 mm**
- **Power consumption reduced by nearly 50%**
- **Saving potential 60 kW**

Increase Stack Height of Cooler Fan

Height (m)	Power	Savings (Rs.Lacs)
23 (Present)	122 kW	--
40	105 kW	3.48
50	90 kW	6.56
60	60 kW	12.7

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Replacing with high efficiency fans

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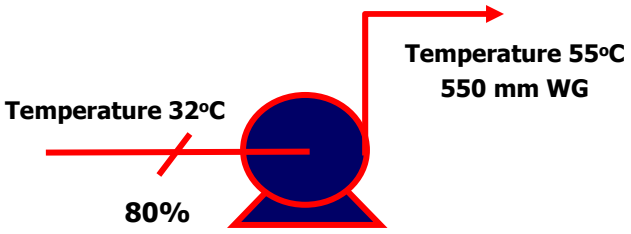
Install High Efficiency Fan for Cooler



- Fan operating efficiency 54%
- Inefficiency – "Churning" of air in Casing
  - Heating of air

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Install High Efficiency Fan for Cooler

- Fan rated for 78% Operating Efficiency
  - Due to wear out & old age – Efficiency lower
- Replaced With New High Efficiency Fan

Annual Savings	= Rs 3.00 lakhs
Investment	= Rs 4.00 lakhs
Payback period	= 16 months

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Efficiency of fans

- Presently fans of high efficiency available for all applications
- Typical target efficiency
  - > 80 % for major fans
  - > 70 % for other fans
- Excellent potential for saving energy

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Matching and control to meet process requirement

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Optimise Dedusting Fan Capacity

- Dedusting essential to reduce dust nuisance
- Packers, Pneumatic conveyors, Mech conveyors transfer points, Crushers

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Optimize Dedusting Fan Capacity

Equipment	Dedusting Qty
Hammer crusher	100 M^3/Hr/Ton
Bucket Elevators	1800 M^3/Hr/M of Bucket Elevator Cross
Pneumatic conveyors	Air lift / FK pump + 50%
Air Slides	Air supplied + 20%
Cement packers	2000 M^3/Hr/Spout
Bins	4000 M^3/Hr/M of bin cross section

A potential area to save energy

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Reduce Silo Top Bag Filter Fan RPM By 20%

- Raw meal silo fed by air lift
  - Raw meal conveying air – 143 m^3/min
  - Air slides - 45 m^3/min

  Others - 13.2 m^3/min

  Total 201.2 m^3/min

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Reduce Silo Top Bag Filter Fan RPM By 20%

- Exhaust Air - 1.5 x Conveying Air
- Existing - 385 m^3/min
- Reduce R.P.M. of exhaust blower by 20%

Annual saving	-	Rs 1.08 Lakhs
Investment	-	Rs 5,000
Payback	-	1 Month

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Optimise operation of Raw Mill Silo-top Bag Filter Fan

- Measured Flow - 21200 m3/h
  - Installed for pneumatic conveying system
- Fan power - 32.25 kW
  - Rated - 45 kW
- Conveying system changed
- Volume of air to be handled reduced

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Optimise operation of Raw Mill Silo-top Bag Filter Fan

- Required flow 8000 m3/h (max.)
- Install smaller size fan
  - 8000 m^3/h
  - 200 mm WC
  - Power - 9 to 10 kW

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Optimise operation of Raw Mill Silo-top Bag Filter Fan

- Further Optimisation of B/F fan
  - Install VFD
  - Maintain Silo draught (50 mmWc)
  - Compressed air based on ΔP (125 mmWC)
- Further reduction in energy consumption

Successful Implementation - Vasavadatta Cements

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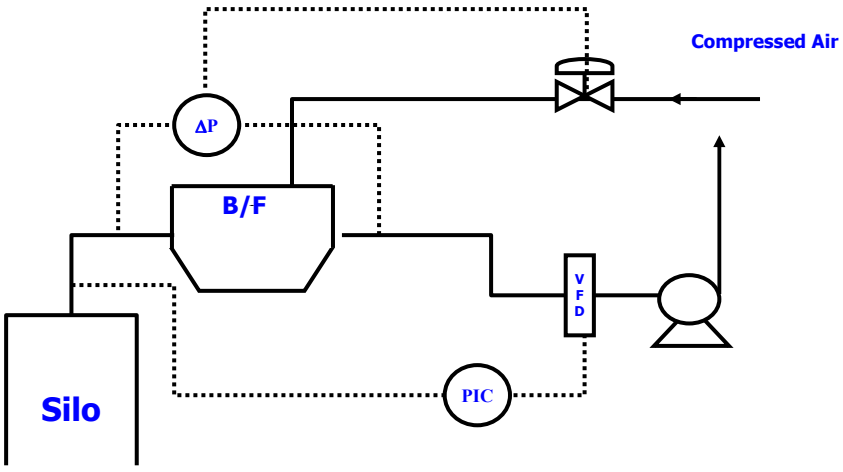
Proposed system



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Optimise operation of Raw Mill Silo-top Bag Filter Fan

Annual saving	-	Rs 5.3 Lakhs
Investment	-	Rs 1.5 Lakhs
Payback	-	4 Months

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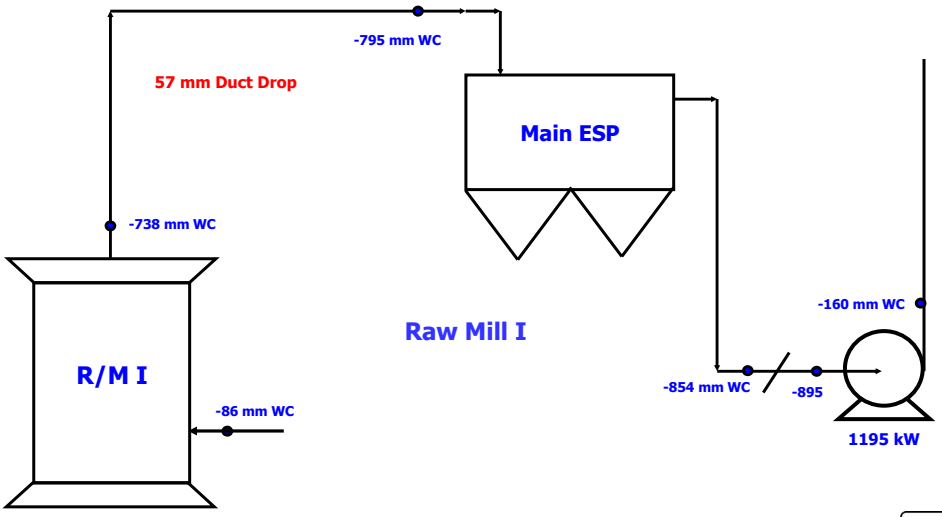
Minimise Pressure drop in ducts of Identified Areas



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Minimise Pressure drop in ducts in identified areas

- Flow & pressure measurements carried out
- Head Developed : 735 mm WC
- Drop in Duct : 57 mm WC
- % drop : 7.7%
- Increased Pressure drop
  - Increased power consumption
- Typical drop : 20 mm WC

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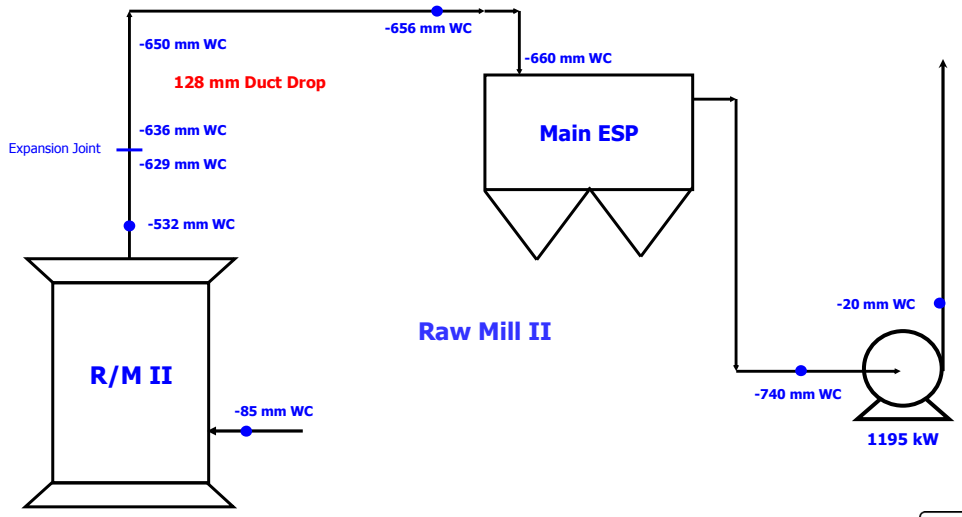
Minimise Pressure drop in ducts of Identified Areas



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Minimise Pressure drop in ducts of Identified Areas

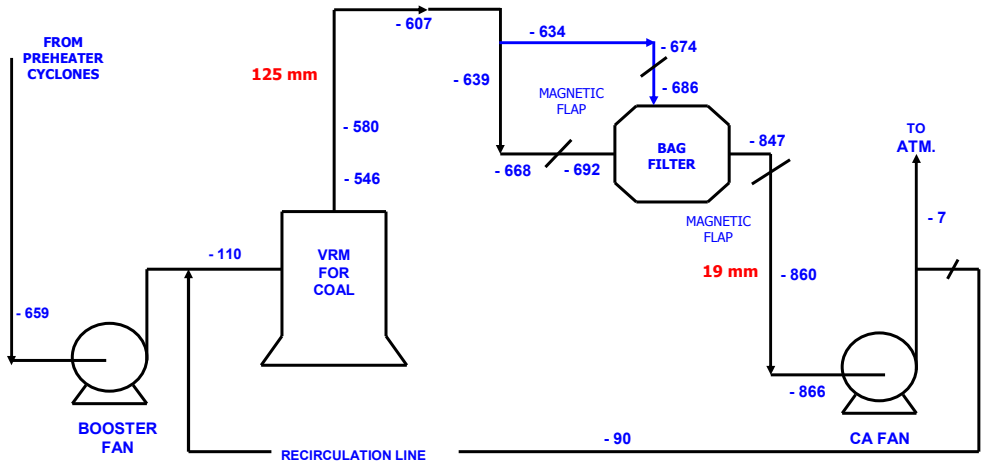
Minimise Pressure drop in ducts in identified areas

- Flow & pressure measurements carried out
- Head Developed : 720 mm WC
- Drop in Duct : 128 mm WC
- % drop : 17.7%
- Increased Pressure drop
  - Increased power consumption
- To be lowered to 40 - 50 mm WC

Minimise Pressure drop in ducts in identified areas

Coal Mill I

(All values in mm WG)

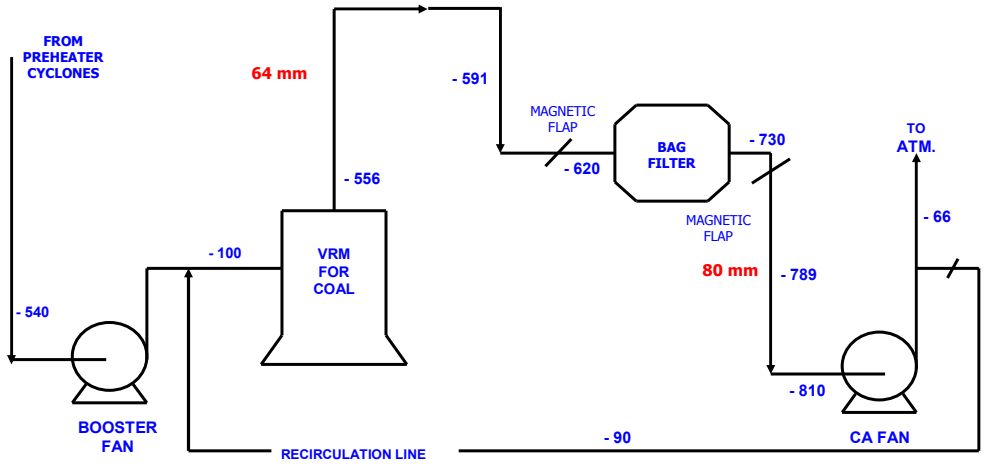


CII

Minimise Pressure drop in ducts in identified areas

Coal Mill II

(All values in mm WG)



CII

Minimise Pressure drop in ducts in Identified areas

- Flow & pressure measurements carried out
- KM I (Mill to BF) : 125 mm WC
  - % Drop ~ 14.55%
- KM II (BF to CA) : 80 mm WC
  - % Drop ~ 10.75%

CII

Minimise Pressure drop in ducts in Identified areas

- Reasons for High pressure drop
  - Bends & Change in cross section of ducts
  - Restrictions due to formation of coatings
  - INFILTRATION
- Good potential to avoid duct drops
- Recommend to
  - Check for pressure drop
  - Target : 10 - 20 mm WC
- Tremendous saving potential

CII

Minimise Pressure drop in ducts in Identified areas

Annual Saving	-	Rs 28.84 Lakhs
Investment	-	Rs.45.00 Lakhs
Simple Payback	-	19 Months

CII

Install VFD for Shell Cooling Fans

- Kiln shell temperature controlled
- 26 Nos. of Shell cooling fans
  - Each of 3.7 kW (2.8 kW, Avg.)
- Fan ON / OFF based on temperature – controlled from CCR
- Fans OFF at temperature of 250^{o}C in critical zones
- ON for majority of time

CII

Install VFD for Shell Cooling Fans

- Good potential to install VFD for shell cooling fans
- Reduce the speed based on temperature
- Maintain speed variation between 250°C to 350°C
- In axial flow fans,
  - Power α Pressure drop α (Velocity)^2

CII

Install VFD for Shell Cooling Fans

- Need to group the fans based on criticality
  - Non critical fans – 4-5 to one VFD
  - Critical fans – 2-3 to each VFD
- Temperature profile to be determined for each zone
- Shell temperature scanner already available
- Need to take this signal to the VFD

CII

Install VFD for Shell Cooling Fans

- A unique initiative
- Good energy saving potential

Annual Saving	-	Rs 2.50 Lakhs
Investment	-	Rs 3.50 Lakhs
Payback period	-	17 Months

CII

Install VFD for CF Silo Aeration Blower

- CF silo aeration blower
  - 6.3 m^3/min, 0.85 kg/cm^2, 18.5 kW
  - Actual power cons: 13.3 kW @ 0.5 kg/cm^2
- Aeration – cycle time based
- Venting for more than 50% of time
- Good potential to install VFD
- Blower to operate at lower speed during non-aeration cycle time

CII

Install VFD for CF Silo Aeration Blower

- Implemented in several plants
- Successful example

Annual Saving	-	Rs 1.33 Lakhs
Investment	-	Rs 1.20 Lakhs
Payback period	-	11 Months

CII

Minimise pressure drop in PH down comer duct

- PH fan – one of the largest energy consumer in the plant
- Preheater downcomer duct pressure drop ~ 80-90 mm

CII

Minimise pressure drop in PH down comer duct

- Good potential for lowering the pressure drop
  - Around 25-30 mm can be lowered
  - Substantial savings ~ 4.46%
- Good potential for energy saving
- Latest trend – carrying out CFD study and minimizing pressure drop

CII

Minimise pressure drop in PH down comer duct

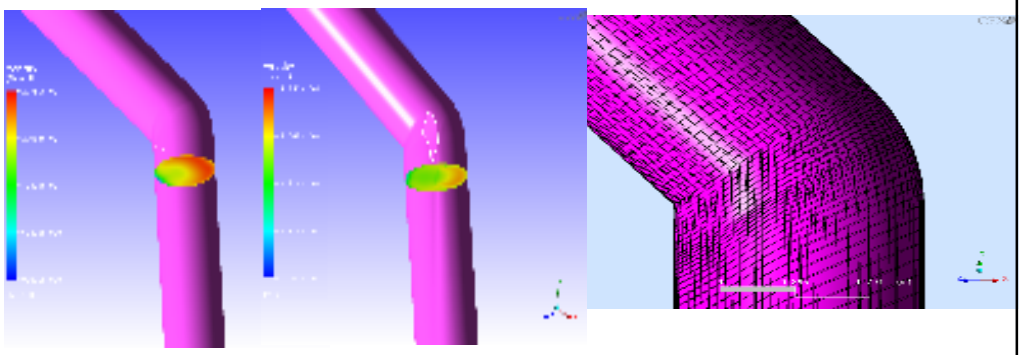
PH downcomer pressure drop – 110 mm WC

CFD study carried out

- Areas of higher pressure drop identified
- Suitable flow diverters & other modifications carried out

CII

Minimise pressure drop in PH down comer duct



CFD Application

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

Minimise pressure drop in PH down comer duct

Annual Saving	**-**	**Rs 24.40 Lakhs**
Investment	**-**	**Rs 10.00 Lakh**
Payback period	**-**	**9 Months**

CII

Thank You

CII