Capacity Building workshop

Energy efficient and Renewable Energy (EE/ RE) Technologies

22nd March 2018 at Thangadh

Under the project
Capacity Building of Local Service Providers (LSPs)

Supported by
GEF-UNIDO-BEE Project
Promoting Energy Efficiency and Renewable Energy in selected

PANCHAL CERAMIC ASSOCIATION
VIKAS TRUST-THANGADH

Table of contents

Workshop summary

Overview of workshop

Capacity Building workshop of Local Service Providers (LSPs) and unit owners on Energy efficiency and renewable energy technology was organized by TERI on 22nd March 2018, Thursday in association with Panchal Ceramic Association Vikas Trust (PCAVT) under GEF-UNIDO project. Total 75 participants were present during the workshop out of which 20 were local service providers (LSPs). Agenda of the workshop and list of participants are attached in the annexure 1 and annexure 2 respectively.

Summary of points discussed in the meeting

Mr. Nanji Bhai trustee, Panchal Ceramic Association Vikas Trust welcomed the participants and thanked the team of TERI and UNIDO for arranging the capacity building workshop. He deliberated the necessity to conserve energy in ceramic manufacturing. He encouraged the participants to take the benefit of the training programme and support the industries in the cluster in order to maintain the optimum efficiency.

Mr. Prabhudas Bhai trustee of PCAVT also welcomed all the participants and appreciated the effort made by TERI and UNIDO for arranging such knowledge sharing workshops of various energy conservation and renewable energy technologies for the ceramic industries.

Inaugural session was attended by other vice presidents/trustees of the PCVAT and they sensitised the participants and encouraged to adopt best operating practices in operations as well as in maintenance.

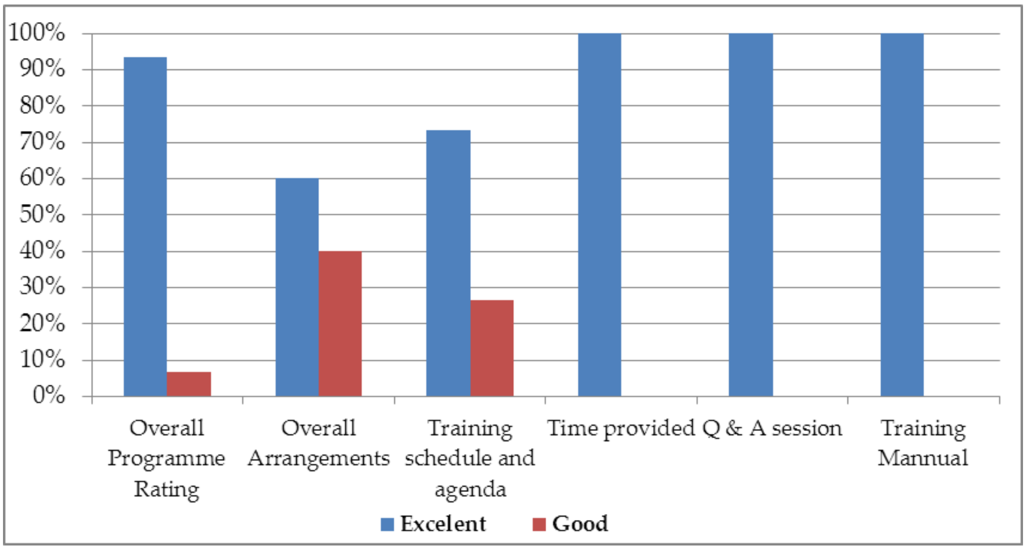
Mr Vora, cluster leader, UNIDO gave a brief background of the GEF-UNIDO-BEE project activities in Thangadh cluster and also explained the objective of the workshop. He informed about the current available equipment's at energy cell and how industries can benefit by availing energy audit services at low costs. He also shared some success stories implemented in the cluster such as energy efficient ceiling fans in drying applications and VFD retrofitting in air compressors.

Mr. Ayan Ganguly gave descriptive presentation on best operating practices in various utilities in the ceramic manufacturing process. He explained the primary reasons which may affect the operational efficiency of the process equipment such as ball mills, kilns, etc. and associate utilities in the ceramic industries. He also discussed about various energy conservation techniques which can be adopted in the existing facilities. He also shared various case studies to optimise the existing thermal and electrical system.

Mr. Pawan Tiwari presented new technologies being used in developed countries and large industries in India which can be easily adopted by our units in order to improve overall energy consumption and quality. He has presented various case studies on new and renewable energy technologies which has a significant effect on reduction of energy consumption.

Feedback forms

Based on the analysis of the feedback forms received from the participants, it is observed that workshop was well received by the participants and 100% participants were satisfied with program, Q&A session and training module provided to them. About 93% participants have rated overall program as "excellent" while rest of them have rated it as "good". More than 90% of participants rated were satisfied with arrangements made, training schedule and agenda of the program. Few sample feedback forms are attached in the annexure 4.



Analysis of feedback forms

Suggestions by participants

Some participants have made suggestions as follows;

1) Technology specific knowledge sharing workshops to be organized frequently
2) Unit level hands on training program on energy efficiency to be organized

Learning's by participants

Some of the topics learned by the participants and mentioned by them are listed below;

1) How to reduce energy consumption in air compressor
2) Low thermal mass application in kiln
3) Adoption of IE3 motors

Annexures

Annexure 1: Agenda of the program

Capacity building workshop

Energy efficient and Renewable Energy (EE/ RE) Technologies

Thursday, 22nd March 2018

Auditorium, PCAVT Building, Thangadh

Under the project:

Capacity Building of Local Service Providers (LSPs)

Supported by:

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Promoting Energy Efficiency and Renewable Energy in selected MSME clusters in India

Agenda

10:30 – 11:00	**Registration**
11:00 – 11:15	**Welcome Address** Mr Kirti bhai Maru, President, Panchal Ceramic Association Vikas Trust
11:15 – 11:30	**Address** Vice Presidents, Panchal Ceramic Association Vikas Trust
11:30 – 12:00	**GEF-UNIDO-BEE project and initiatives in Morbi cluster** Mr P. Vora, UNIDO Cluster Leader - Thangadh
12:00 – 13:00	**Energy conservation opportunities in Ceramic manufacturing process** Mr Ayan Ganguly, TERI
13:00 – 14:00	Lunch
14:00 – 15:00	**New and renewable energy technologies options in Ceramic manufacturing process** Mr Pawan Tiwari, TERI
15:00 – 16:00	**LSP Presentations** **Q&A**
16:00 – 16:15	**Vote of thanks** Mr Ashwin Bhai, Panchal Ceramic Association Vikas Trust

Organized by

The Energy and Resources

Panchal Ceramic Association Vikas Trust

Annexure 2: List of participants

The Energy and Resources Institute

PANCHAL CERAMIC ASSOCIATION VIKAS TRUST-THANGADH

Capacity building workshop

Energy efficient and Renewable Energy (EE/ RE) Technologies

22nd March 2018, Auditorium, PCAVT Building, Thangadh

S. No	Name	Organization	Mobile No	Email ID	Signature
1.	Manan Patwari	Milestone Pneumatics Ahmedabad	9904805701	manan@milestonepneumatics.com	[signature]
2.	Vishwas Virda	Atlas Copco	9898686964	vishwasvirda93@gmail.com	[signature]
3.	Bhavesh C. Raval	C.U. Shah College of Engg. & Technology, C.U. Shah University	9879154659	bhavesh.eee.ccet@gmail.com	[signature]
4.	Vaibhav Mehta	C.U. Shah College of Engineering & Tech. Surendranagar	8469924935	vaibhavkmehta@yahoo.com	[signature]
5.	Archit Shah	Atlas Copco	9925152991	archit.shah@globalairtechsystems.com	[signature]
6.	Gopal Trivedi	ELGi Equipments Ltd.	7490024975	gopal@elgi.com	[signature]

S. No	Name	Organization	Mobile No	Email ID	Signature
7.	N Shyam Sundar	M/s ELGI EQUIPMENT (?)	[illegible]	shyamsundar@elgi.com	[signature]
8.	SANJAY DHARODIYA	SIMANDHAR CERAMIC	9913323062	—	[signature]
9.	Jignesh Prajapati	Saroj Refractories	9426497723	—	[signature]
10.	Jigar. I. Savadiya	Parmar Ceramic	8601866940.	—	[signature]
11.	UPENDRA. N. BHORANIA	Ratnadeep ceramic	9825830812	—	[signature]
12.	PALAK SUTHAR	Elgi Aircomp milestone Pneu	9904805705	Services @ milestone pneumatic	[signature]
13.	Ashish Solanki	Elgi Aircomp milestone Pneu	9904805703	Sales @ milestone Pneumatic	[signature]
14.	Vimal Savadiya.	Golden Ceramic	9979601068.	—	[signature]
15.	Ishvarbhai Varia Tileworks Co	Varia TilesWorks Co	9825236255		[signature]
16.	Nanjibhai Bhorania	Reliance Ceramics	9825564995		N Bhorania

S. No	Name	Organization	Mobile No	Email ID	Signature
17	Bharatbhai Dave	Aditya Ceramics	9427667835		[signature]
18	Jogesh Patel	Elgi Equipments	9724326706		[signature]
19	Ajitbhai Vyas	Fire clay suppliers	9712698239		[signature]
20	સમરાઈજ પોટરી વર્કસ	પાર્ટનર	૯૮૨૫૨ ૧૭૬૪૨		
21	શંકર સેનેટરીવેર્સ પ્રા. લી.	ડાયરેક્ટર	૯૮૨૫૨ ૧૮૧૭૭		
22	[illegible]	Portmate.	9426649964		[signature]
23	Vishal Gohil	Vishwakarma Ind.	9913554143		[signature]
24	K.D Gohil	Vishal Cera Art	9824245577		[signature]
25	ગુરૂકૃપા સેરામીક્સ	વિષ્ણુભાઈ ભગત પાર્ટનર	૯૮૨૫૨ ૧૭૭૧૮		
26	Indian Ceramics	[illegible]	૯૮૨૫૦ ૫૪૩૩૩		[signature]

S. No	Name	Organization	Mobile No	Email ID	Signature
27	Dharmil Patel	Empire Compressor Ind.	99099 68852	dharmil@empire compressor.com	[signature]
28	Solvi sanitary	Ravibhai	8405099999	Selvi sanitary@gmail.com	[signature]
29	Sundaro ceramic	[signature]	9979499402		[signature]
30	[illegible]	[illegible] mo=98256 232	[illegible]		
31	[illegible]	[illegible]	98252 76205		
32	NEW LIGHT CERAMIC	Jayendrabhai	98252 18199	newlight ceramic@gmail.com	JK.[illegible]
33	Nikom Chauhan	D-vinci Enterprise	94601 8460126586	Dvincienterprise@gmail.com	[signature]
34	Mulia Brothers	Rustone	9537777218	[illegible]mulia@icloud.com	[signature]
35	PIYUSH THAKER	SIEMENS LTD.	9909904993	piyush.thaker@siemens.com	[signature]
36	TUSHAR R. PATEL	PREMIER DHARERRACK PVT. LTD.	9824284009	tushar_pppl@hotmail.com	[signature]

S. No	Name	Organization	Mobile No	Email ID	Signature
37	Golden Ceramic	Kishanbhai	98258 25661	bhoraniyakishan2010@gmail.com	[signature]
38	MUKESH SHAH	DEEP CERAMIC INDUSTRIES	9879520628		[signature]
39	RAJESH SHAH	RAJDEEP CERAMIC INDUSTRIES.	9825191827		[signature]
40	anand Joshi	Colors Ceramics	9727277477		[signature]
41	Marvi ceramic [illegible]	Kirtibhai Prajapati [illegible]	9898988456		[signature]
42	Sweta pottery ware	Navin	9825078841		
43	[illegible]	[illegible]	9427045483		[signature]
44	[illegible]	[illegible]	9427045483		[signature]
45	[illegible]	[illegible]	7069039202		[signature]

S.No.	Name	Organsation	Mob. No.	Email id	Signature
46.	Sarvodaya Ceramic	HaRakjibhai			[illegible]
47.	Sonic Natvarbhai	Sonic ceramic			[illegible]
48	Ashok bhai	Gajendra Ceramic			[illegible]
49.	Jayesh bhai	Bajaj Sanitary ware			[illegible]
50.	Bhatukbhai Loomi ma	Sanitary ware			Bhatukbhai
51.	Mohit. Mohan	oswal potters works		oswal potters works @ yahoo.in	Mohan
52.	Haresh Prajapati Jeevandeep Ceram.	Sanitary ware		jeevandeepceramics@gm	[illegible]
53.	Himatbhai Lanco Sanitaryware	Sanitaryware		lomatlakhtariya@yahoo.com	[illegible]
54	Kushik Ceramic	Tarun & Patel	98254 45653		[illegible]
55.	શિવશક્તિ સિરામિક	દેવજી નાગિનભાઈ શાહ			[illegible]
56.	ફ્લોરા સિરામિક	પાર્ટનર મેહુલભાઈ શાહ	૯૪૨૭૦ ૭૫૪૮૩		[illegible]
57	ડાયનામિક સિરામિક	શાંતિલાલભાઈ પટેલ	૯૮૨૫૨ ૨૨૫૨૦		
58.	Rydeep Ceramic Ind	Rajesh S. Shah	9825191828		[illegible]
59	New Light Ceramic	Jinal J. Marvy	937777771(		[illegible]

Sr. No	Factory Name	Desing. Name of owner.	Mo. No	Sing
60	Astha ceramic	Sakhanpara Nikul L.		[signature]
61	[illegible]	[illegible]	98256 95709.	ઘનશ્યામભાઈ
62	[illegible]	[illegible]	9980993600	[signature]
63	[illegible]	[illegible]	98252 24261	
64	[illegible]	[illegible]	98252 17673	
65	Max Ceramic Ind	Mayur Shah	98252 17678	[signature]
66	New Light Ceramic.	Jinal Maru	9377777711	[signature]
67	Pradip vora	Cluster leader Umdo	9824384234	[signature]
68	Champion Ceramic	Sanjay bhai	9825216591	[signature]
69	Yuvraj Ceramic	Rathod	9825637717	[signature]
70	[illegible]	[illegible]	9924500880	Pankaj

Sr.No	Name	Organisation	email id	mobile no.	Sign.
71	ભગવાનજી ભીમાભાઈ	[illegible]	9979000981		
72	ઉદય રવિકુમાર.	જૂનાગઢ	9979000981		
73	સંજય સગરામભાઈ.	ગોંડલ	98252 18212		
74	મફતા સગરાભાઈ	ફુલજીભાઈ પ્રજાપતિ	૯૮૭૯૩ ૩૨૫૮૯		
75	આરતી સગરાભાઈ	અમૃતલાલ શાહ	૯૮૨૫૨ ૧૭૬૩૯		
76					
77					
78					
79					
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81					

Annexure 3: Selected photographs of the event

Annexure 4: Sample feedback forms

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Thursday, 22nd March 2018

Auditorium, PCAVT Building, Thangadh

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Promoting Energy Efficiency and Renewable Energy in selected MSME clusters in India

Evaluation Sheet for Participants

Feedback Form for Participants			
Parameter	*Feedback*		
	Excellent	Good	Average
How would you rate the overall programme?	✓		
How would you rate overall arrangements?	✓		
How was the training schedule and agenda?	✓		
How was the industrial site visit?	✓		
Do you think that adequate time was provided for each topic?	Yes [✓]	No [ ]	
Do you think that satisfactory answers were given to your questions during the training programme?	Yes [✓]	No [ ]	
Do you think that the background training manual is informative and useful enough?	Yes [✓]	No [ ]	
Do you think that the discussion on EE/RE will help you in your work?	Yes [✓]	No [ ]	

Suggestions & Recommendations for improvement:

Name two learning, which from this programme you will be able to implement in your plant?

First, I don't know what is I2 motor and I3 motors, I [illegible] here, Second, V.F.D. air compressor, it's very important for us. Now I try to Both changes in My factory

Signature: [signature]

Name of participant: SANJAY K. DHAROJIYA

Organization: SIMANDHAR CERAMIC

Mobile No: 9913323062

Email ID: simandharceramic@yahoo.in

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	Excellent	Good	Average
How would you rate the overall programme?	✓		
How would you rate overall arrangements?	✓		
How was the training schedule and agenda?	✓		
How was the industrial site visit?	✓		
Do you think that adequate time was provided for each topic?	Yes [✓]	No [ ]	
Do you think that satisfactory answers were given to your questions during the training programme?	Yes [✓]	No [ ]	
Do you think that the background training manual is informative and useful enough?	Yes [✓]	No [ ]	
Do you think that the discussion on EE/RE will help you in your work?	Yes [✓]	No [ ]	
Suggestions & Recommendations for improvement:			
Name two learning, which from this programme you will be able to implement in your plant?			
Signature: Avk			
Name of participant: Vishwas Virda			
Organization: Atlas Copco			
Mobile No: 9898686964			
Email ID: vishwasvirda93@gmail.com			

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gef UNIDO ENERGY IS LIFE BEE CONSERVE IT

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Parameter	*Feedback*		
	Excellent	Good	Average
How would you rate the overall programme?	✓		
How would you rate overall arrangements?	✓		
How was the training schedule and agenda?	✓		
How was the industrial site visit?			
Do you think that adequate time was provided for each topic?	Yes [✓]	No [ ]	
Do you think that satisfactory answers were given to your questions during the training programme?	Yes [✓]	No [ ]	
Do you think that the background training manual is informative and useful enough?	Yes [✓]	No [ ]	
Do you think that the discussion on EE/RE will help you in your work?	Yes [✓]	No [ ]	
Suggestions & Recommendations for improvement:			
Name two learning, which from this programme you will be able to implement in your plant?			
Air Compressor with VFD			
IE3 motor			

Signature:	
Name of participant:	[illegible]
Organization:	Manjari deep ceramics
Mobile No:	
Email ID:	

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Feedback Form for Participants			
Parameter	***Feedback***		
	Excellent	Good	Average
How would you rate the overall programme?	✓		
How would you rate overall arrangements?	✓		
How was the training schedule and agenda?		✓	
How was the industrial site visit?		✓	
Do you think that adequate time was provided for each topic?	Yes [✓]	No [ ]	
Do you think that satisfactory answers were given to your questions during the training programme?	Yes [✓]	No [ ]	
Do you think that the background training manual is informative and useful enough?	Yes [✓]	No [ ]	
Do you think that the discussion on EE/RE will help you in your work?	Yes [✓]	No [ ]	

Suggestions & Recommendations for improvement:

good Program. It has to repeated frequently

Name two learning, which from this programme you will be able to implement in your plant?

—

Signature: [signature]

Name of participant: JT Shyam Sundar

Organization: M/s ELGI EQUIPMENT LTD

Mobile No: 9766695043 9766695043

Email ID: shyamsundram@elgi.com

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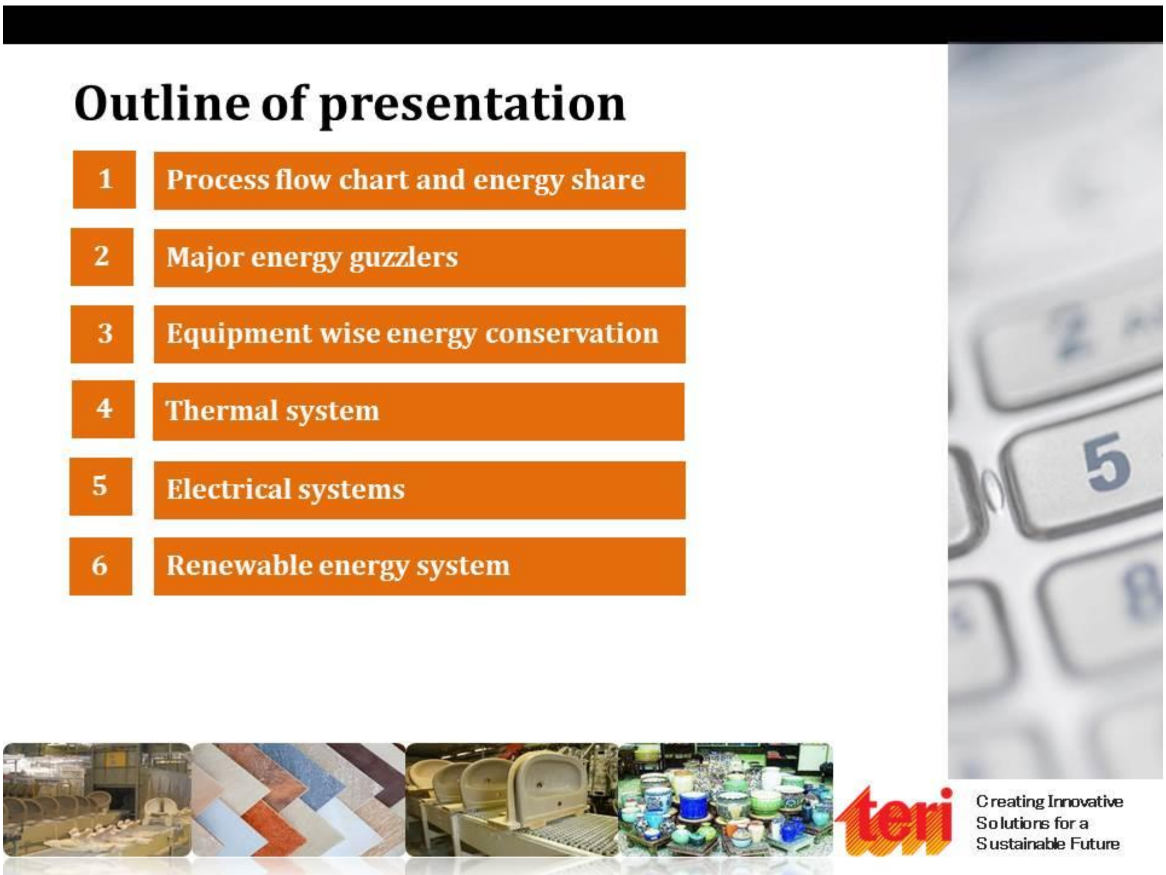
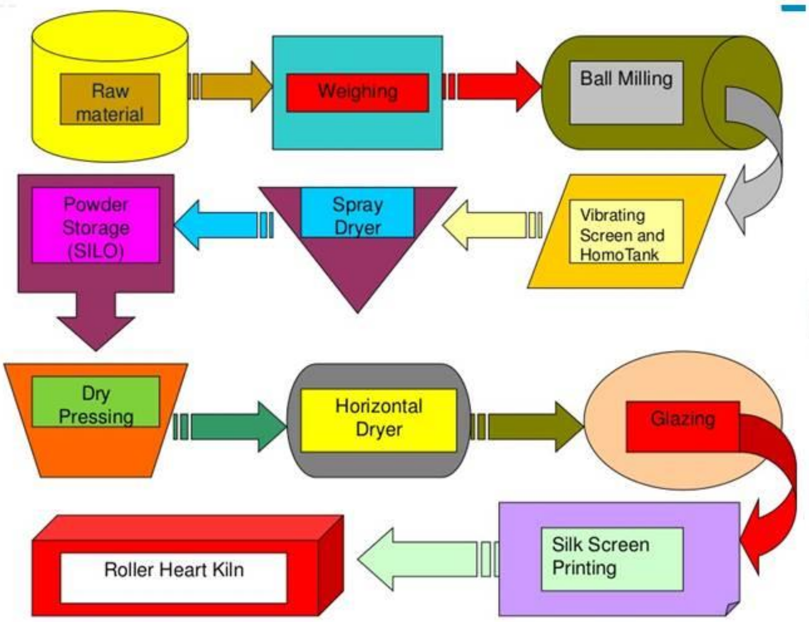
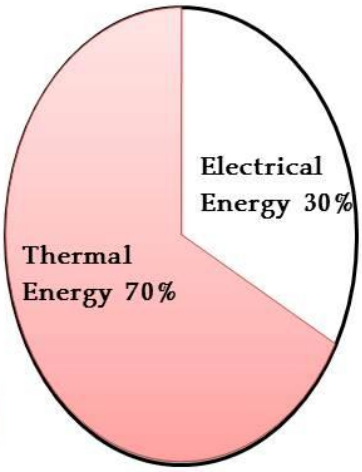
Annexure 5: Copy of presentations



Process flow chart and energy share





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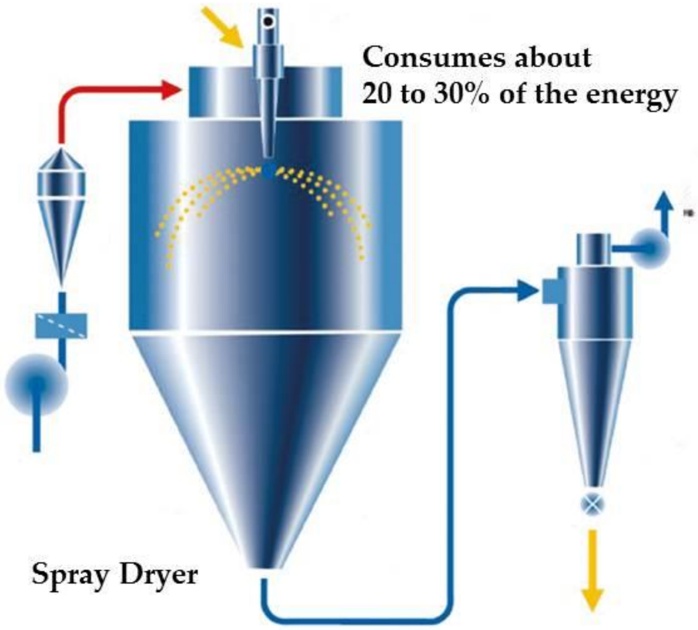
Major energy consumer and their share



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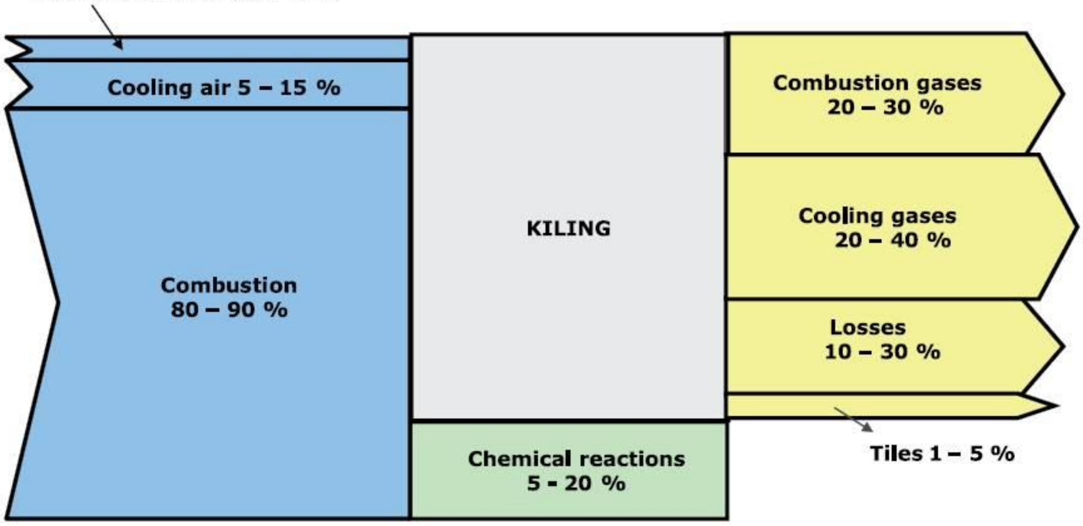
Shan-key diagram for kiln



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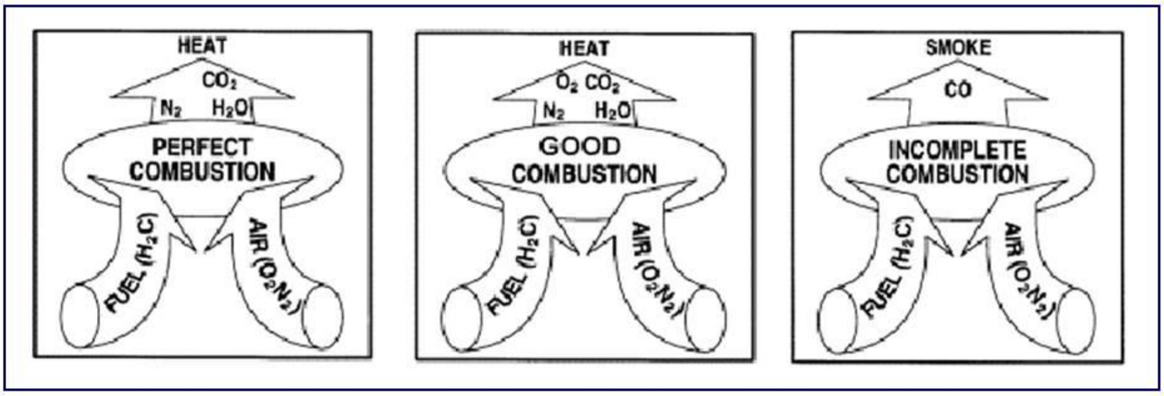
Combustion



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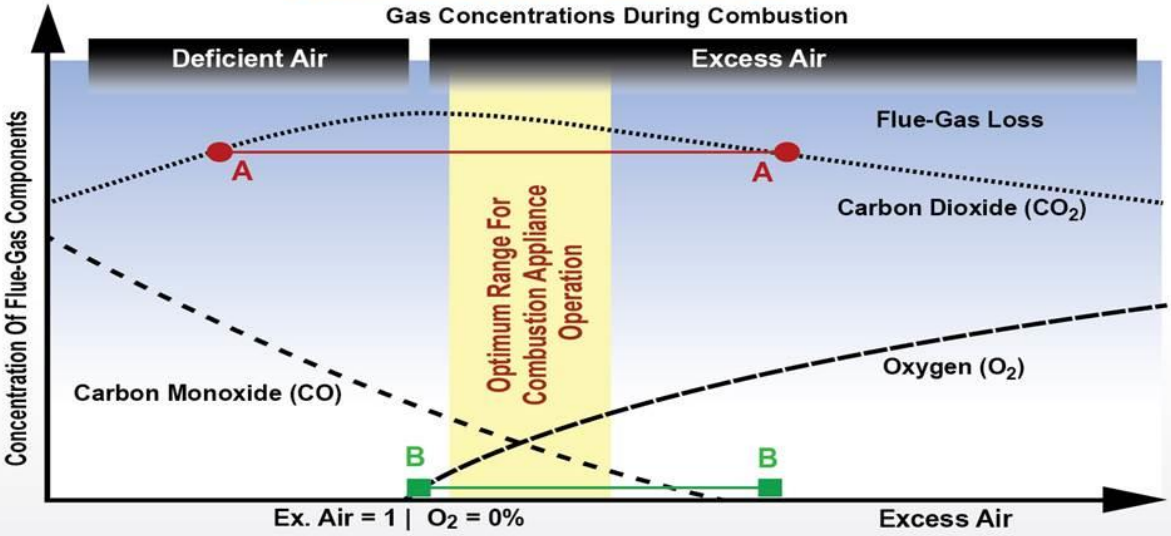
Combustion Control



A: CO_2 readings are identical at both points. CO_2 reading does not reveal whether appliance is running fuel rich (expensive) or lean (preferred).

B: Preferred range of operation with excess air. O_2 concentration is zero at perfect combustion and will display falling O_2 readings in fuel rich ranges.

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Benefits of combustion control

- Reduce excess fuel consumption.
- Reduce blower power consumption
- Increases exhaust temperature
- Give higher benefits in preheated combustion air as well as in dryer applications

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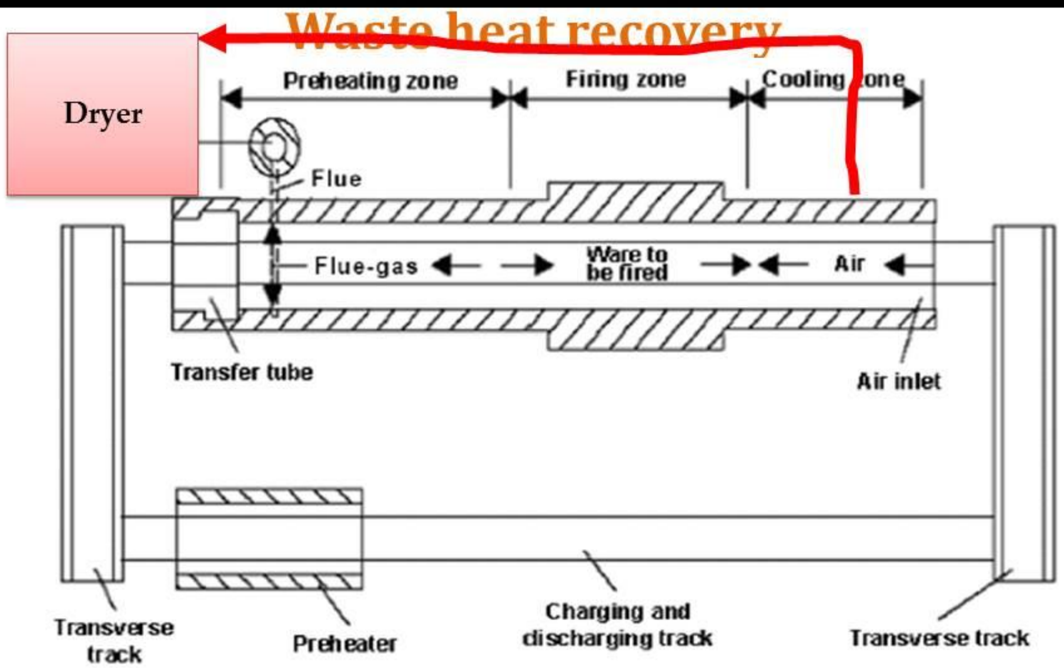
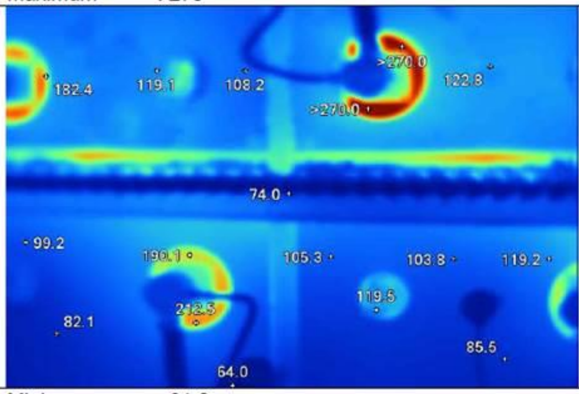
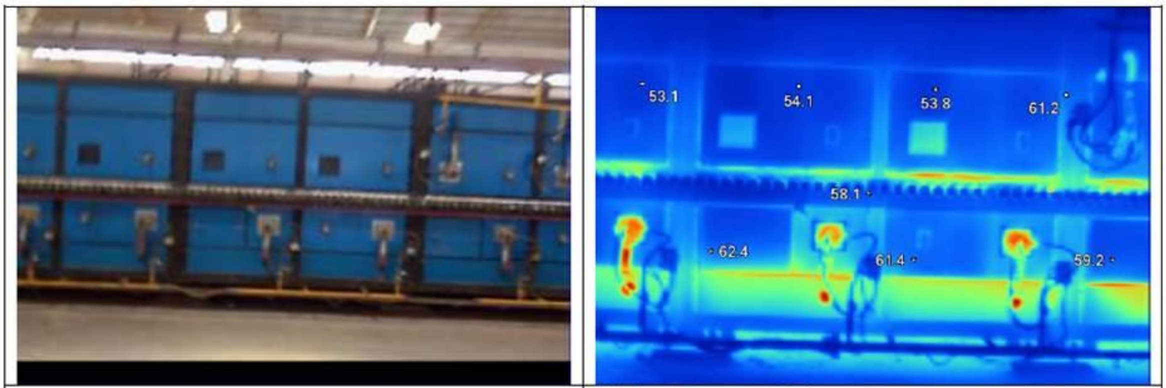


Reduction of radiation loss



Description:- Firing zone Module 21 of Biscuit Kiln (RHS)	Minimum : 61.0 Average : 165.5 Maximum : 270



Description:- Firing zone Kiln (LHS)	Minimum :44.3 Average :62.9 Maximum :123.5

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Electric Motor

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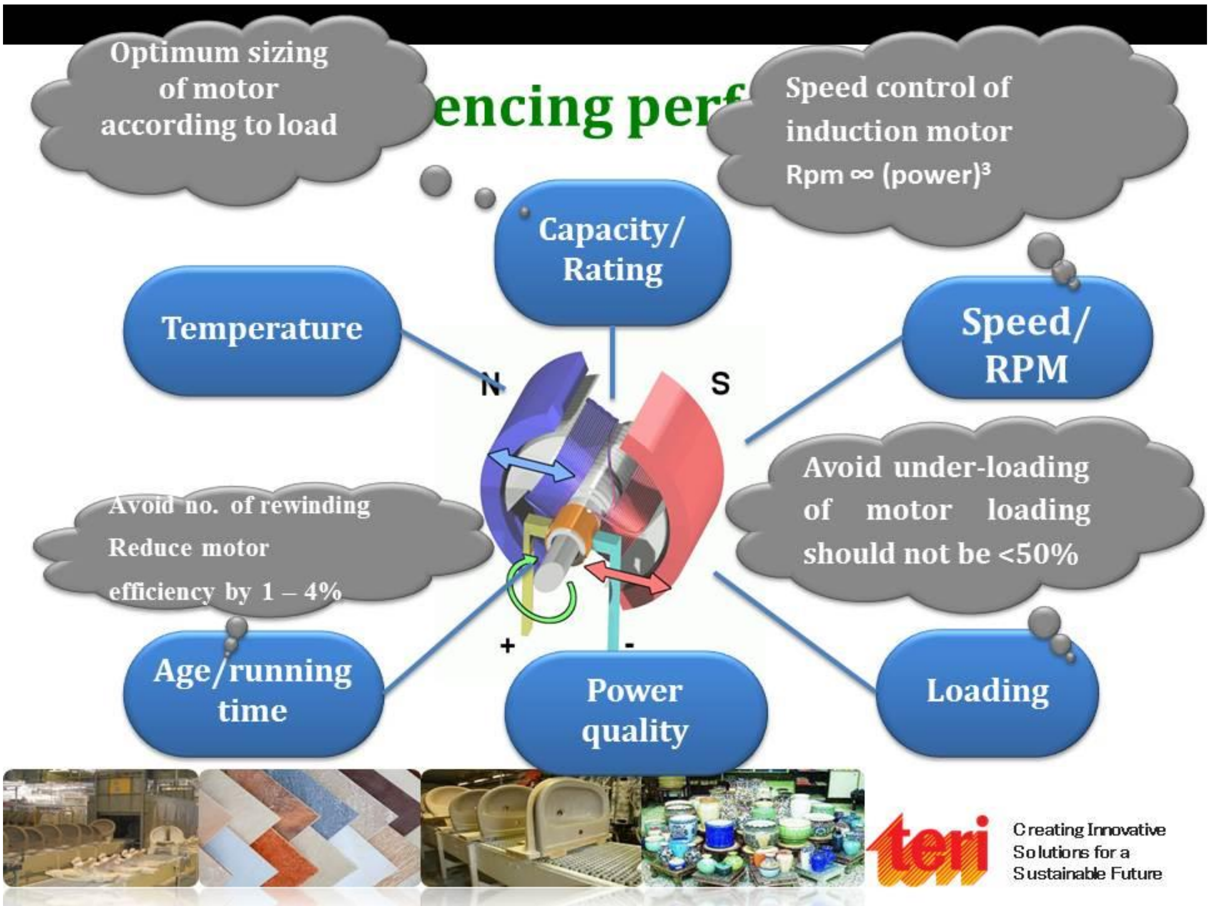
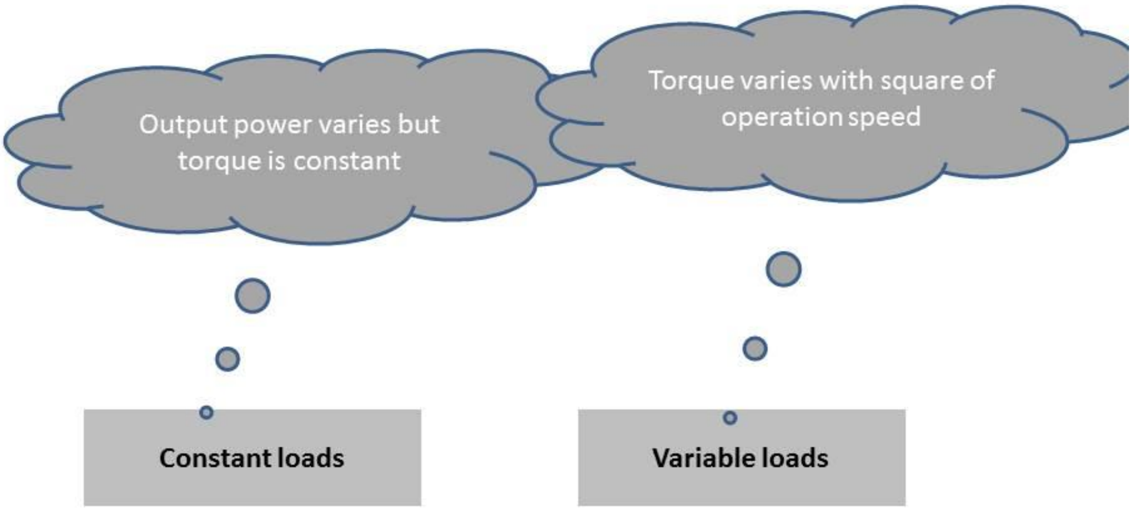


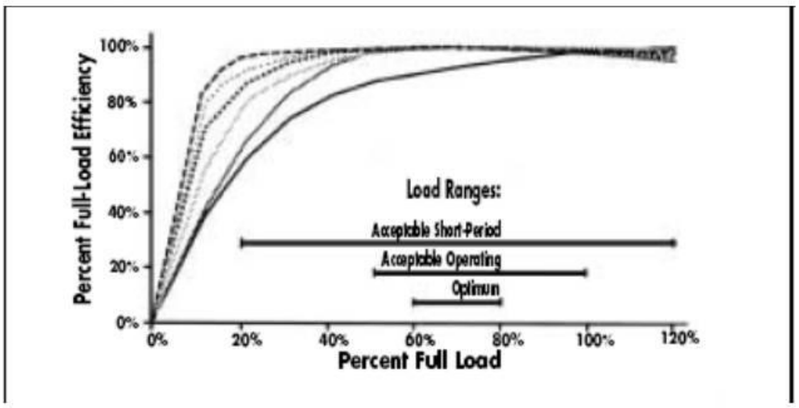
What are the type of Motor Load



Efficiency of Electric Motors

Motor part load efficiency

- Designed for 50-100% load
- Most efficient at 75% load
- Rapid drop below 50% load



Energy efficiency opportunities in motors

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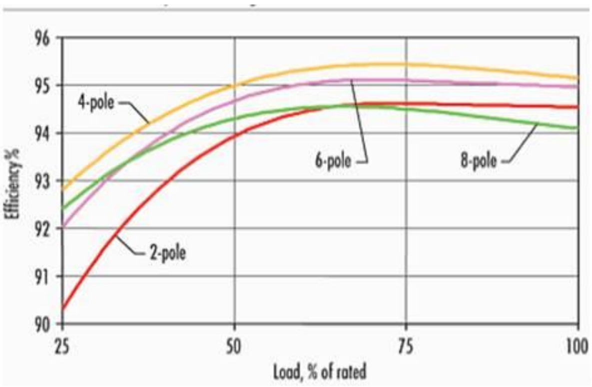
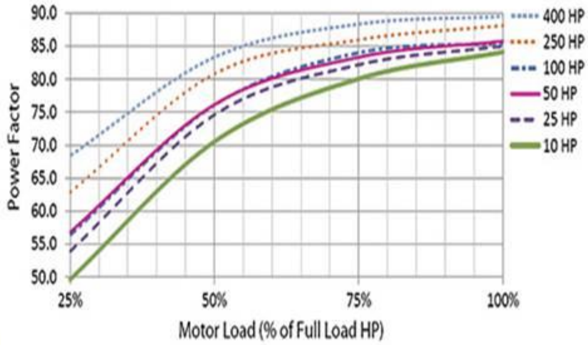
Avoid under-loading of motor



✓ **Efficiency and power factor drastically fall down as the loading decreases below 50%**



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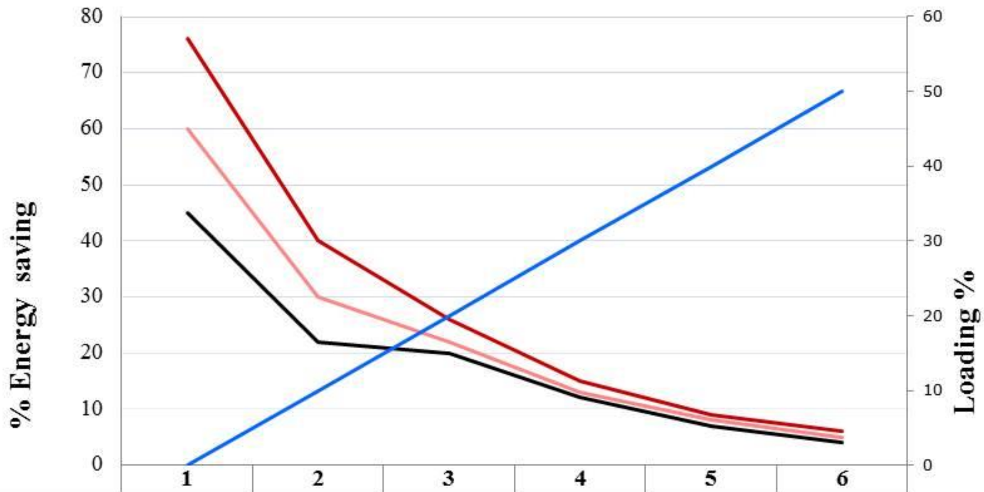
Use of Star delta Convertor



	1	2	3	4	5	6
1 TO 15 HP	76	40	26	15	9	6
16 TO 40 HP	60	30	22	13	8	5
41 TO 150 HP	45	22	20	12	7	4
Load %	0	10	20	30	40	50

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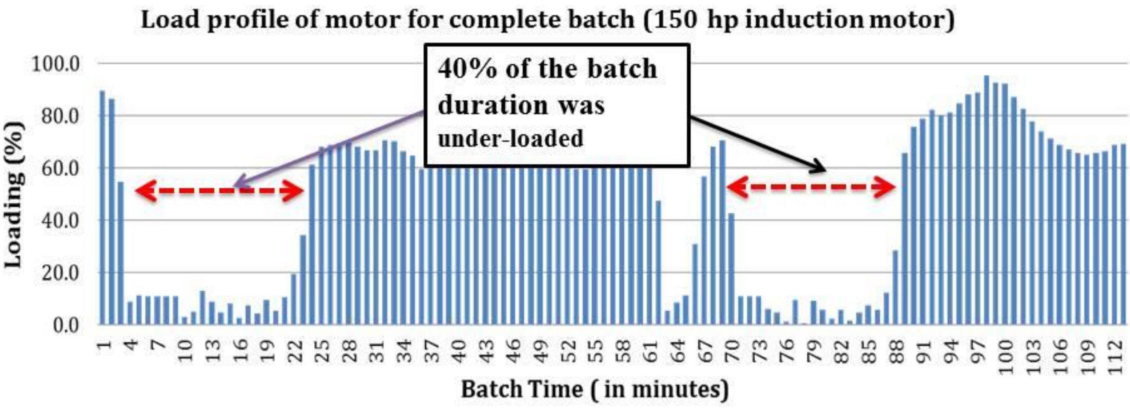
Case study of star- delta convertor



Average saving was estimated to be about 22% with a simple payback period of 9 months

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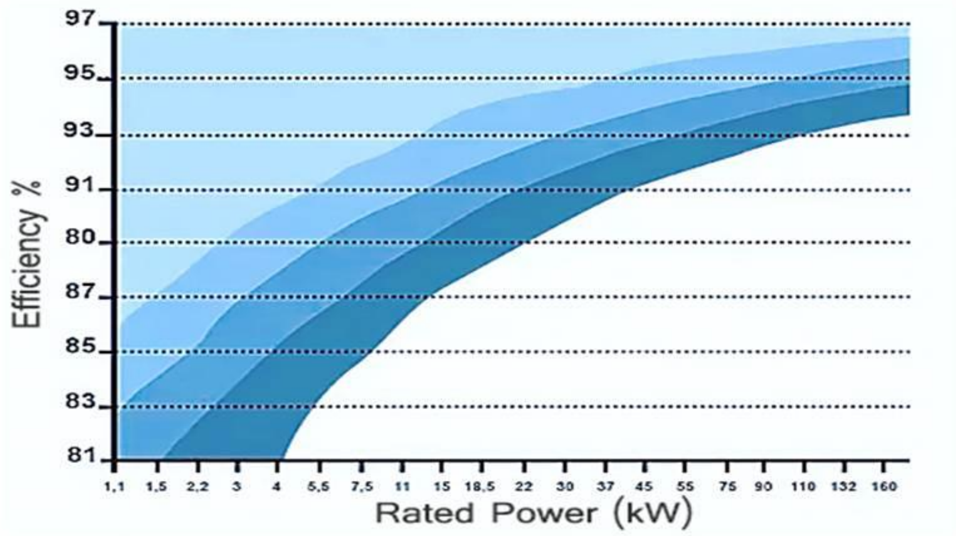
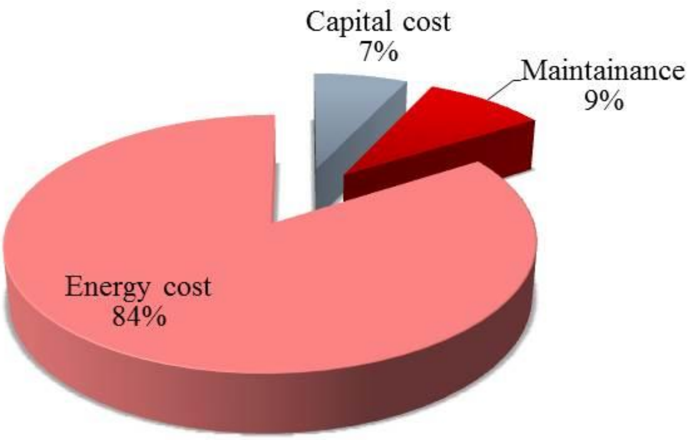
Use of high efficiency motors (IE2, IE3)



Share of capital cost and running cost



Fixed loss (iron)
- Use of **thinner gauge**, **lower loss core steel** reduces **eddy current losses**
- **Longer core** adds more steel to the design, which reduces losses due to **lower operating flux densities.**

Stator I^2R
- Use of **more copper** & **larger conductors** increases cross sectional area of stator windings.
- This lower **resistance (R)** of the **windings** & reduces **losses due to current flow (I)**

Rotor I^2R
- Use of **larger rotor conductor** bars increases size of cross section.
- **lowering conductor resistance (R)** & losses due to current flow (I)

Friction & Winding
- Use of **low loss fan** design reduces **losses due to air movement**

Stray Load Loss
- Use of optimized design & **strict quality control** procedures minimizes **stray load losses**

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Case Study: Replacement of rewinded standard motors with energy efficient motors

- About 37 number of standard efficiency motors of rated 3.7 kW to 22 kW are found to be re-winded.
- Rewinding leads to a drop in the efficiency.
- Efficiency improvement with IE3 motor:
  - Annual Energy Savings : 1.5 Lakh kWh
  - Annual Cost Savings : Rs. 4.58 Lakhs
  - Cost of Implementation : Rs. 12.50 Lakhs
  - Payback Period : less than 3 years

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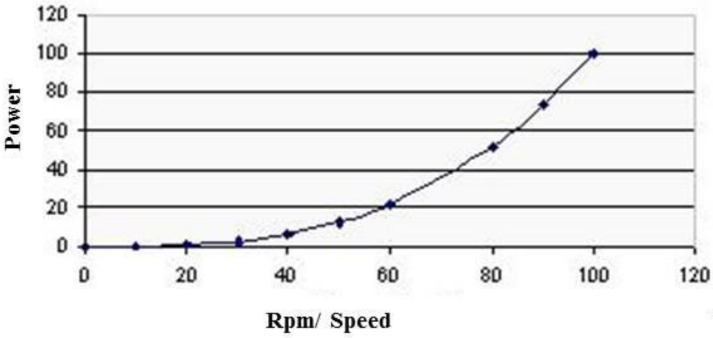
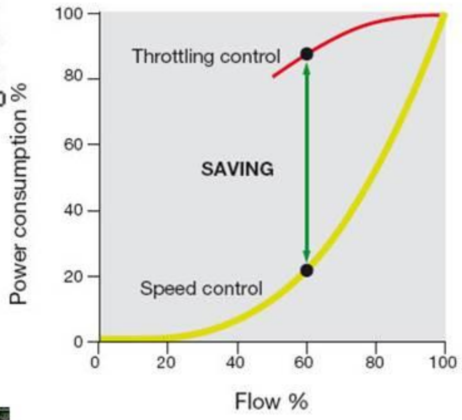
Speed control of induction motor





- ✓ **For variable loading , like in case of pump with a variable load can reduce it flow by lowering its RPM and generate substantial saving**

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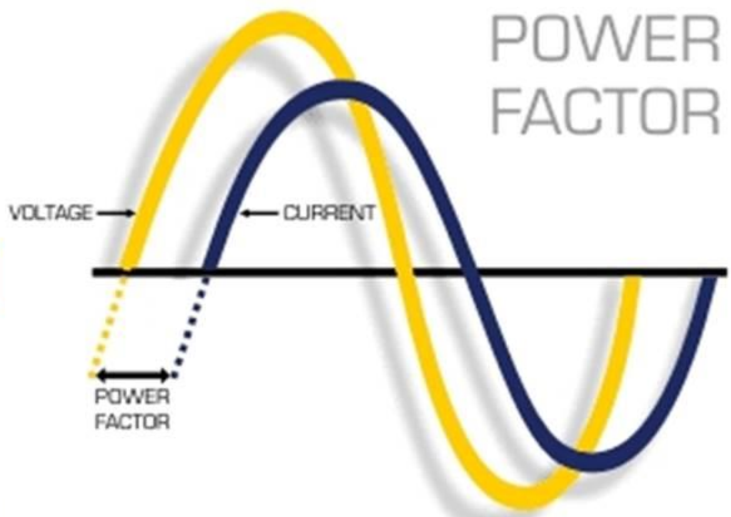
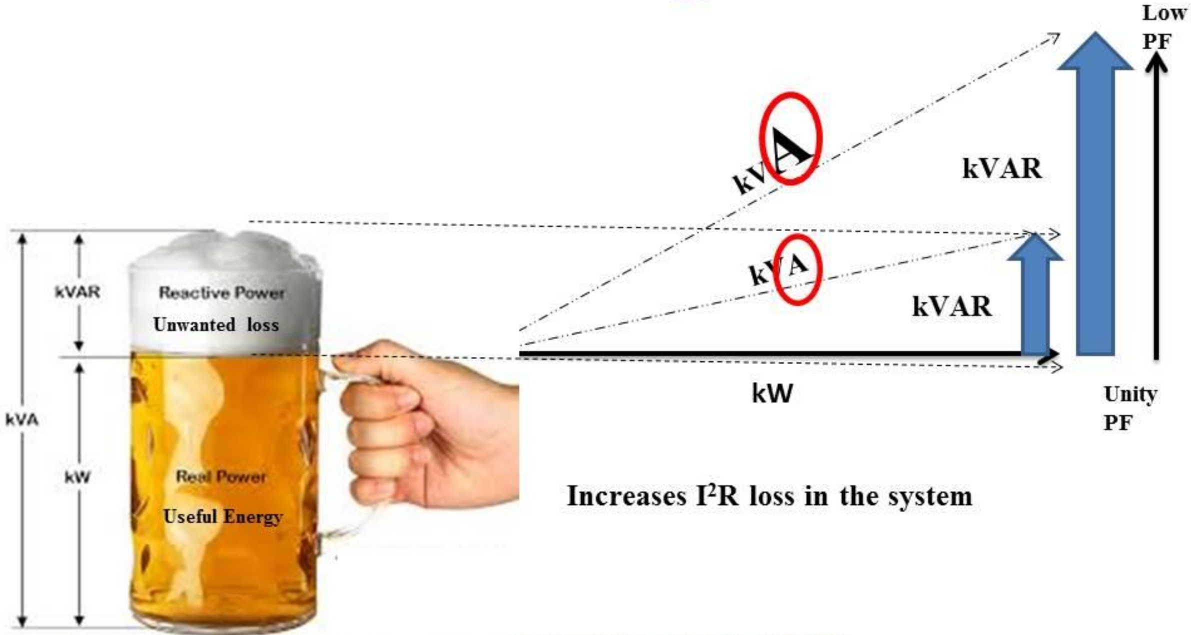
Type of Electrical Systems In Industry

✓ Reactive Power



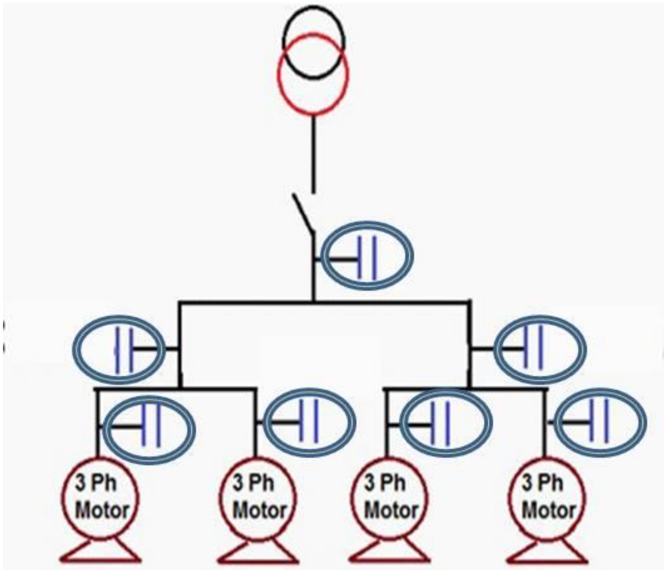
Solutions for a Sustainable Future

Reactive Power Management



Increases I^2R loss in the system

How to Improve PF of the System



- Identification of source.
- Estimation of required kVAr compensation
- Sizing of capacitor banks
- Installation of fixed type capacitor bank at the load end.
- Installation of Automatic power factor controller at the main incomer.

(appropriate stages should be provided as per load requirement)

Load End Capacitor Requirements

Motor Rating (HP)	Capacitor rating (kVAr) for Motor Speed					
	3000	1500	1000	750	600	500
5	2	2	2	3	3	3
7.5	2	2	3	3	4	4
10	3	3	4	5	5	6
15	3	4	5	7	7	7
20	5	6	7	8	9	10
25	6	7	8	9	9	12
30	7	8	9	10	10	15
40	9	10	12	15	16	20
50	10	12	15	18	20	22
60	12	14	15	20	22	25
75	15	16	20	22	25	30
100	20	22	25	26	32	35
125	25	26	30	32	35	40
150	30	32	35	40	45	50
200	40	45	45	50	55	60
250	45	50	50	60	65	70

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Improve power quality

Motor performance affected by

- Poor power quality: too high fluctuations in voltage and frequency
- Voltage unbalance: unequal voltages to three phases of motor

Improve power quality

- Keep voltage unbalance within 1%
- Balance single phase loads equally among three phases
- Segregate single phase loads and feed them into separate line/transformer

Parameters	Example 1	Example 2	Example 3
Voltage unbalance (%)	0.30	2.30	5.40
Unbalance in current (%)	0.4	17.7	40.0
Temperature increase (°C)	0	30	40

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Compresses air system

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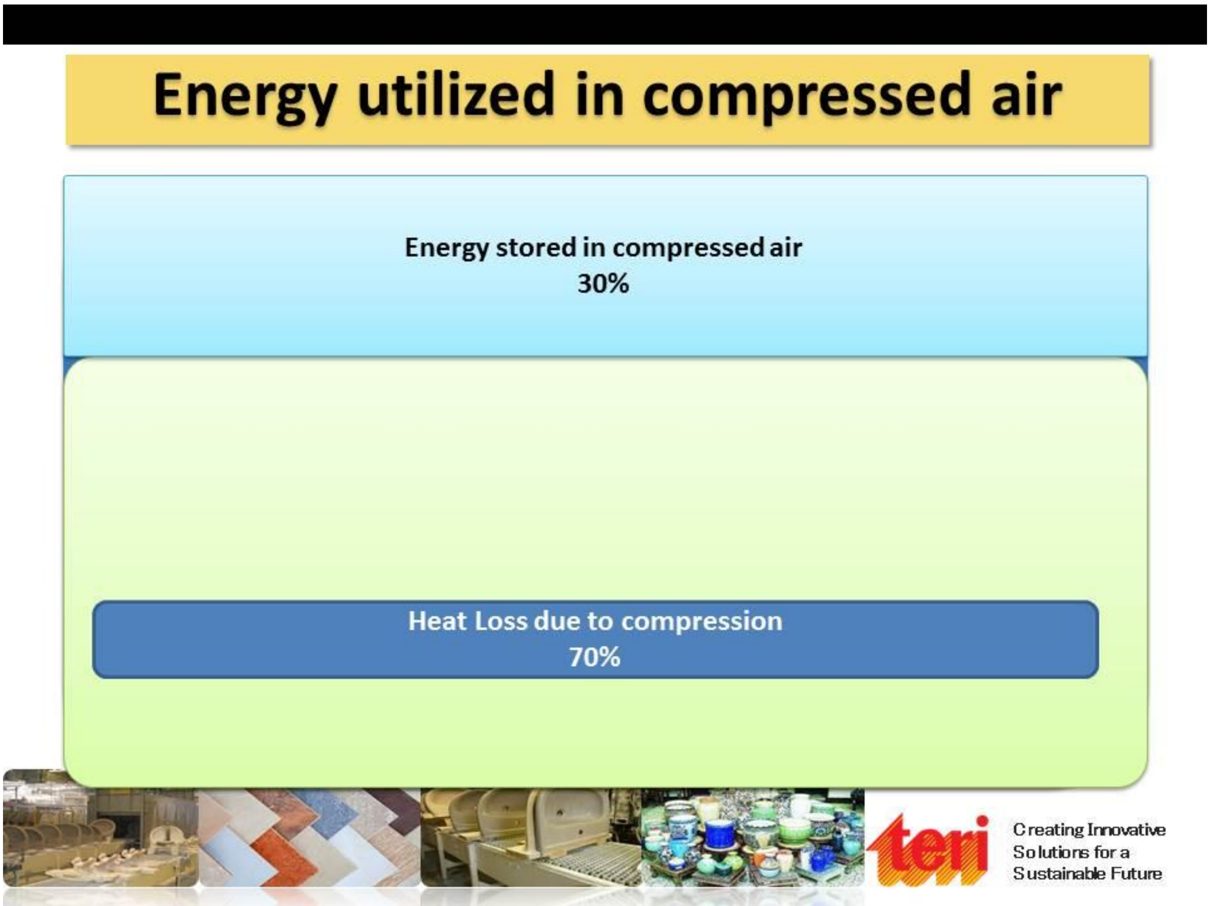
Energy utilized in compressed air
Energy stored in compressed air
30%
Heat Loss due to compression
70%
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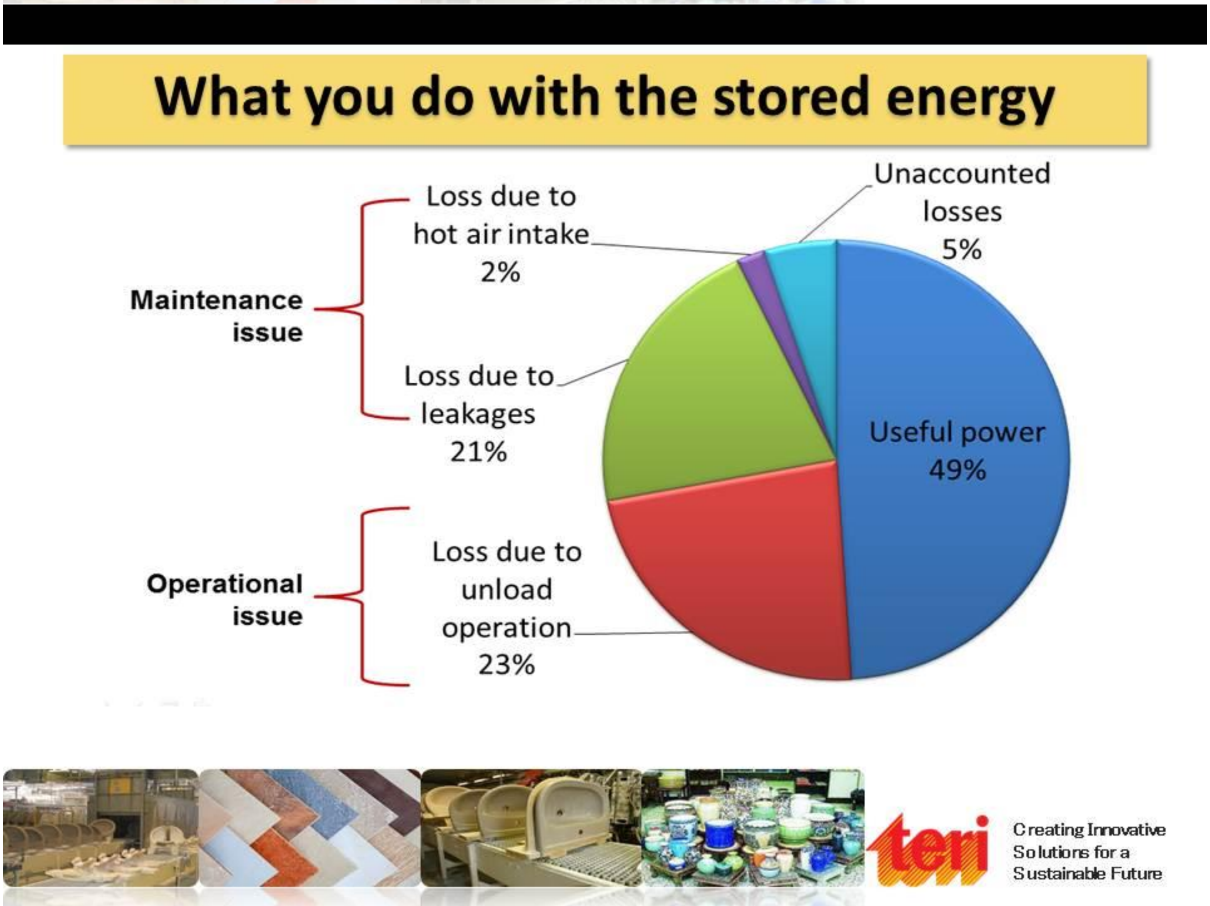
What you do with the stored energy
Maintenance issue
Loss due to hot air intake
2%
Loss due to leakages
21%
Operational issue
Loss due to unload operation
23%
Unaccounted losses
5%
Useful power
49%
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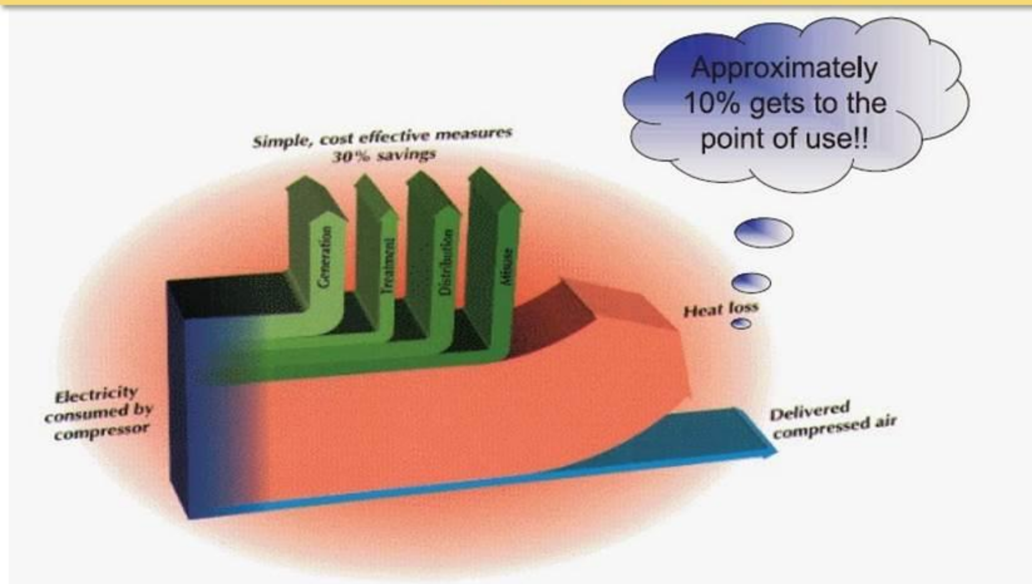
Actual energy at usage point



Sankey Diagram for Compressed Air System

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What can you save ?

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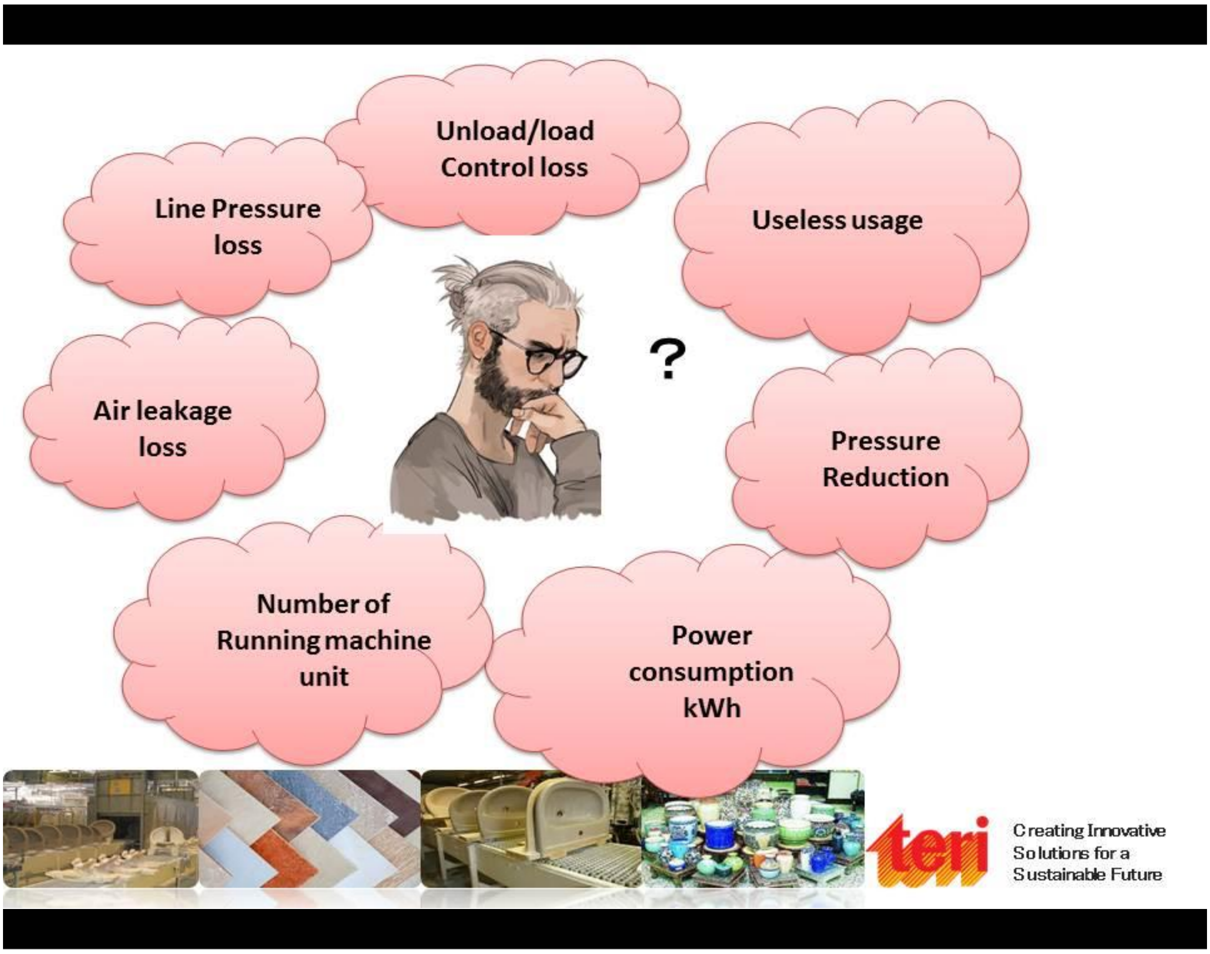

How can you save ?

Assessment of compressor

- **Volumetric efficiency/ Free air delivery (FAD)**
  - FAD reduced by ageing, poor maintenance, fouled heat exchanger and altitude
  - Energy loss: percentage deviation of FAD capacity
- **Leakages**
  - Energy waste proportional to input energy
  - Drop in system pressure results in high generation pressure
  - Shorter equipment life

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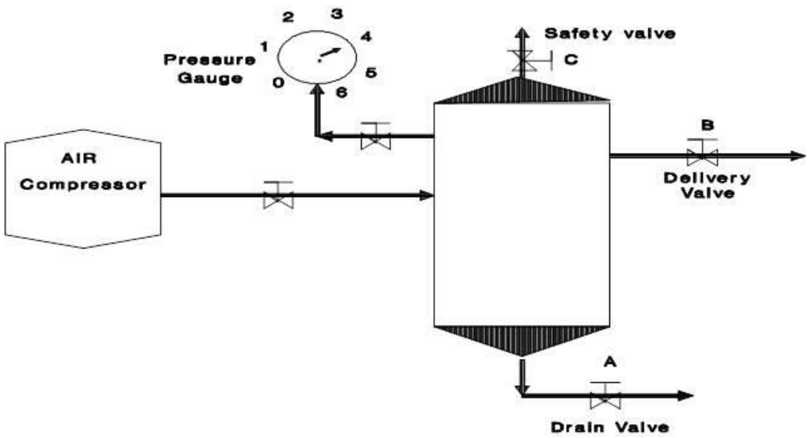
Capacity assessment method

- Isolate compressor and receiver; close receiver outlet
- Empty the receiver and the pipeline from water
- Start the compressor and activate the stopwatch
- Note time taken to attain the normal operational pressure P_2 (in receiver) from initial pressure P_1



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Capacity assessment method ... contd.

Calculate the capacity FAD

$$Q = \frac{(P_2 - P_1)}{P_0} x \frac{V}{t}$$

Q = Free air delivery (m^3/min)

P_2 = Final pressure after filling (kg/cm^2a)

P_1 = Initial pressure after bleeding (kg/cm^2a)

P_0 = Atmospheric pressure (kg/cm^2a)

V = Storage volume including receiver, after cooler and delivery piping (m^3)

t = Time take to build up pressure to P_2 (minutes)

In case of high suction air temperature as compared to ambient air temperature, use correction factor $(273+T_{ambient})/(273+T_{suction})$

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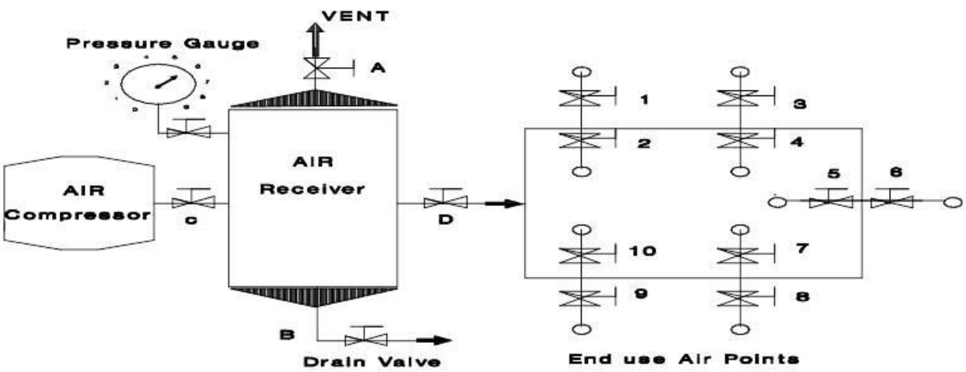
Leakage Quantification Method

- System to be on No Load i.e. no usage of compressed air
- Switch the compressor ON
- With a stopwatch, note time taken to load and unload the compressor
- Run test for 30 minutes



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Leakage quantification method

Calculate quantity of leakage*

$$Q_L = \frac{Q \ x \ t_{on}}{(t_{on} + t_{off})}$$

Q_L = Leakage quantity (m^3/min)

Q = Free air delivery (m^3/min)

t_{on} = On load time i.e. loading period (seconds)

t_{off} = Off load time i.e. unloading period (seconds)

In a well maintained system, compressed air leakages are below 10%

*This test is not applicable for VFD based air compressor

Energy Saving Opportunities

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Installation of energy efficient air compressor

Before

- Rated FAD – 1.48 m^3/min
- Type – Reciprocating
- Operating pressure – 10 kg/cm^2
- Specific power consumption – 9.23 kW/m^3/min

After

- Rated FAD – 1.60 m^3/min
- Type – Screw
- Specific power consumption – 6.88 kW/m^3/min
- % Energy savings – 25.5%
- Simple payback period – 2.5 years

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Inlet air temperature is higher and generation pressure is way more than demand

Solutions

- Ensure ambient temperature air is available at suction point
- Optimize compressed air generation pressure.

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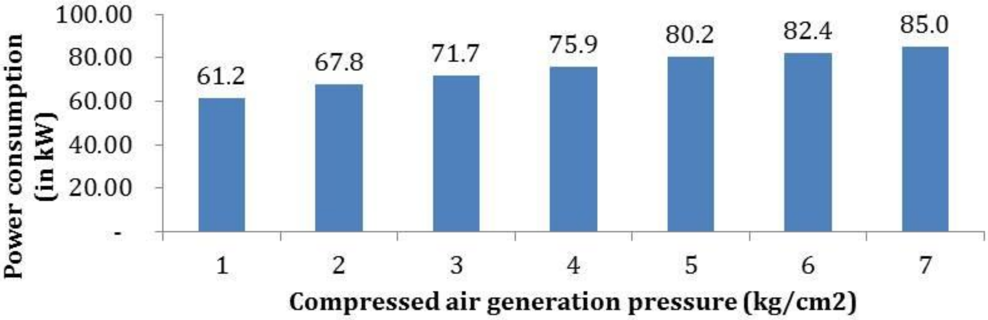
Reduction in compressed air generation pressure and inlet air temperature

Compressed air generation pressure was 7 kg/cm2



- Compressed air pressure requirement at demand side – 4 to 5.5 kg/cm^2
- Reduce compressed air generation pressure from $7 kg/cm^2$ to $6 kg/cm^2$
- % energy saving was 3.1%, annual electricity savings of 63,490 kWh
- Annual monetary savings of Rs. 3.6 Lakhs

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High compressed air leakages in the plant

Solutions

- Replace leaking regulator, joints, pipes and junctions
- Use air amplifier for cleaning purpose

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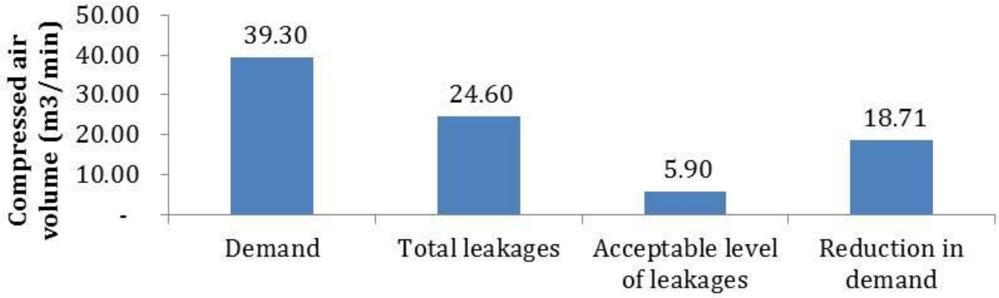
Arresting leakages of compressed air distribution system

Percentage leakages of 62.8% in compressed air distribution network of a food industry



- 66 leakages points were identified and plugged.
- % energy saving was 48%, annual electricity savings of 1,010,578 kWh
- Annual monetary savings of Rs. 59.7 Lakhs, simple payback of 1 month

Screw type compressor with unload condition greater than 10% of the operating time

Solutions

- Install VFD on screw compressor

Installation of VFD on compressed air system

Before

- Rated FAD – 2.52 m^3/min
- Operating pressure – 8.5 kg/cm^2
- Specific power consumption – 8.4 kW/m^3/min
- Load to unload ratio – 53:47

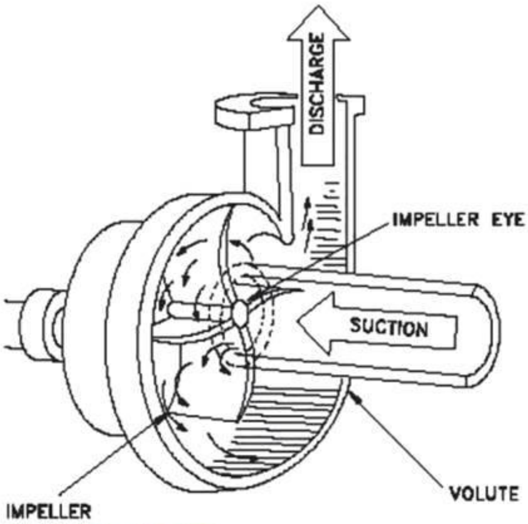
After

- Annual electricity saving – 26,247 kWh
- Annual monetary savings – Rs. 2.1 Lakhs
- % Energy savings – 24.1%
- Simple payback period – 1 year

Pumping system

Pumps

- Pump converts electrical energy into hydraulic energy
- Pumps handling any fluid can be broadly classified as dynamic and displacement pumps.
- Dynamic pumps:
  - Centrifugal pumps: They are the most common pumps
  - Special effect pump



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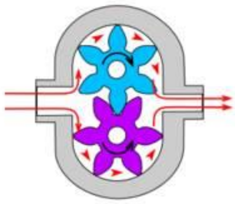
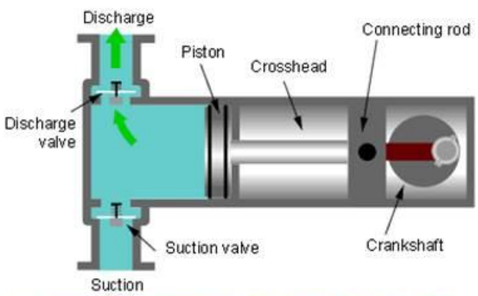
Pumps

- Displacement pump:
  - Rotary



  - Reciprocating



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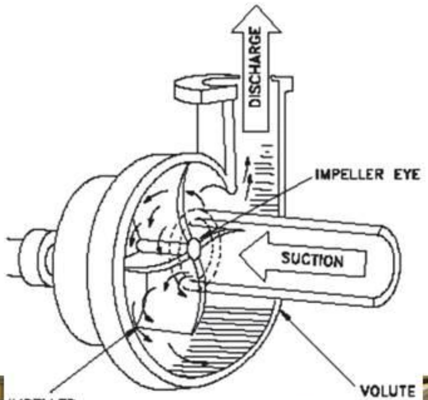
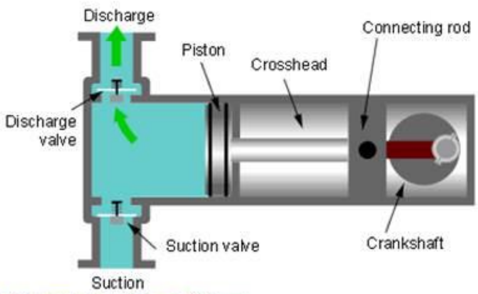
Comparison

- Displacement pumps are more efficient than dynamic pumps however efficiency benefits are offset by higher maintenance cost





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System characteristic

- Objective of the pump in most cases is to transfer fluid from source to destination.
- To do that it has to maintain a pressure to overcome pipe/system/head losses
- Head losses type:
  - Static head
  - Dynamic/friction head

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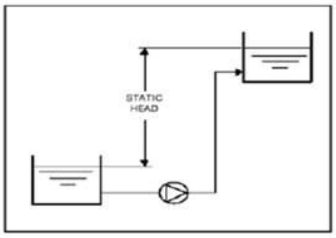
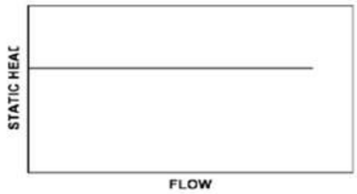
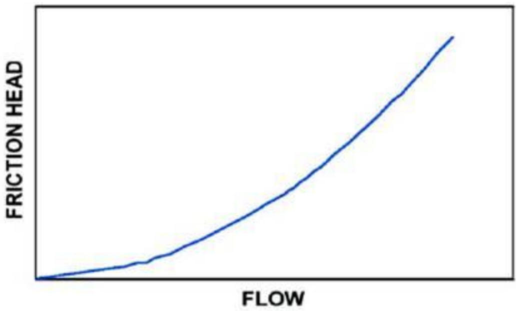
Static and friction head

- Static





- Friction



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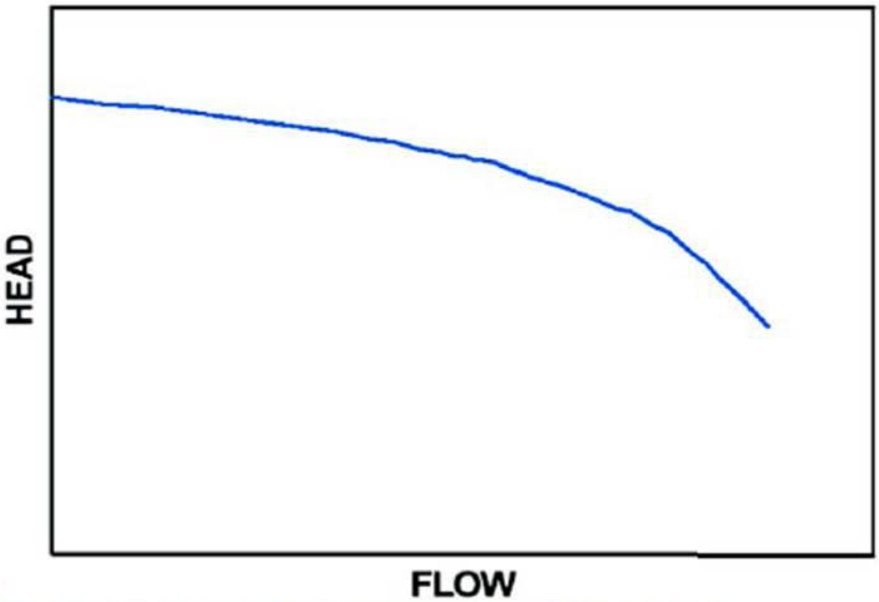
Pump performance curve



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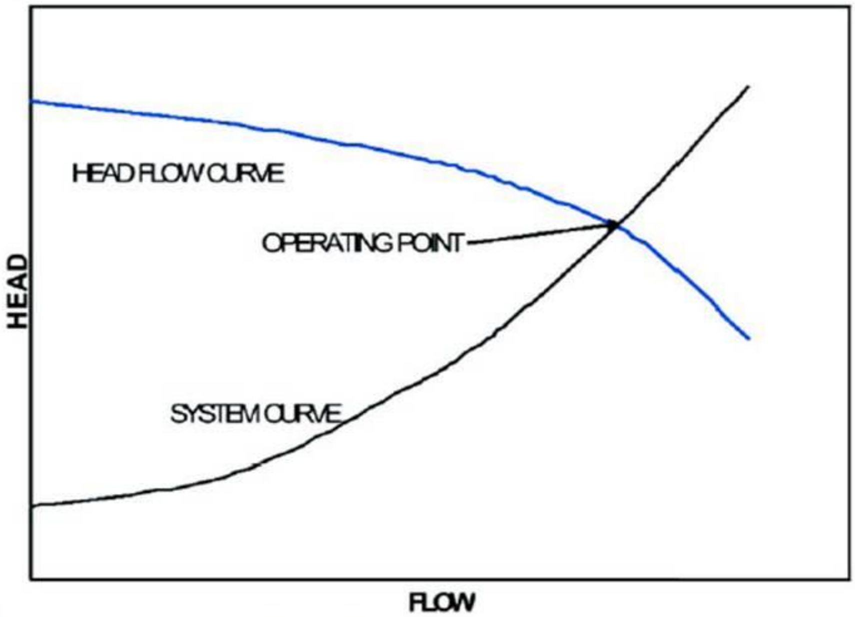
Operating point



Pump equations

- Hydraulic power = (Flow x density x Total head x g)
  - Hydraulic power in kW
  - Flow in cubic meter per second
  - Density in kg per cubic meter
  - Total head = discharge head – suction head
  - g, acceleration due to gravity – 9.81 m/s^2
- Pump efficiency (%) = (Hydraulic power/Power at shaft) x 100
- Power at shaft (kW) = (Power input to motor x motor efficiency)

Performance assessment of pump

Step -2
Measure flow, discharge and suction pressure

Step -3
Measure instantaneous power

Step -4
Enquire about piping circuit, whether the water path remains same or varies with process

Step -1
Note the name plate details

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Mismatch of pump performance and system requirement

Solutions

- Install appropriate design pump

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Installation of Energy efficient pumps

Case of mismatch of pump design parameters and system requirement parameters in captive power plant

Particular	Unit	Before	After
Design parameters			
Flow	m3/hr	2,500	2,800
Head	meters	25	15
Rated Power	kW	300	160
Operating parameters			
Flow	m3/hr	2,613	2,954
Head	meters	13	13
Actual Power consumption	kW	197	143
Pumping system efficiency	%	47	73
Annual electricity savings	kWh/year		473,040
Annual monetary savings	Rs./year		1,442,772
Simple payback period	Year		0.9

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Pumps with different design parameters operating in parallel mode

Solutions

- Install two similar design pumps

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Parallel pumping with different design pumps

Case of medium scale pulp and paper manufacturing plant

Particular	Unit	Dominating pump	Dominated pump
Existing (different design pumps operating in parallel mode)			
Flow	m3/hr	425	198
Head	meters	23	23
Actual Power consumption	kW	39	36
Pumping system efficiency	%	68.2	34.9
Proposed (same design pump, one working one standby)			
Flow	m3/hr		625
Head	meters		23
Power consumption	kW		48
Pumping system efficiency	%		82.4
Annual operating hours	hours		7,008
Annual electricity savings	kWh/year		187,692
Annual monetary savings	Rs./year		959,153
Simple payback period	Years		1.1

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Water requirement in the plant is variable

Solutions

- Install Variable frequency drive and operate it as per process requirement

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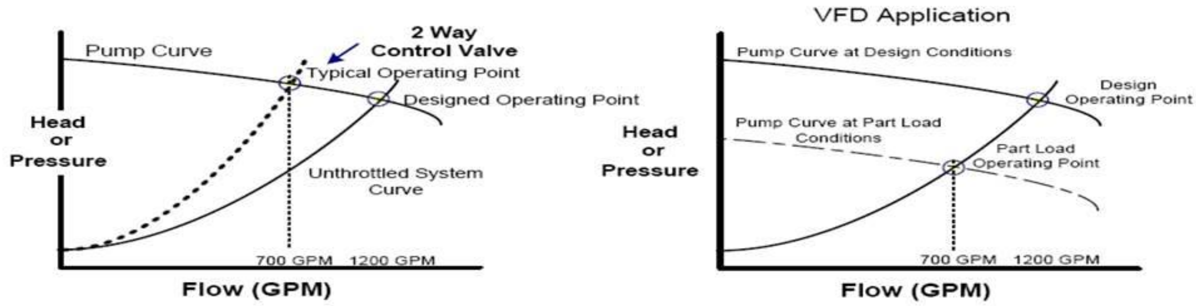
VFD on variable loaded pump



- 7.5 kW cooling tower pump caters cooling requirement of two condensers and one reaction vessel.
- When pump operates for condensers alone (part load) its operating efficiency is 38.6% and during full load operating efficiency is 64.2%.
- Part load conditions exists for 72% of operating time.
- Install VFD to reduce operating flow and head during part load.
- % electricity saving is 9.1%, simple payback period is 1.8 years

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Cooling Tower

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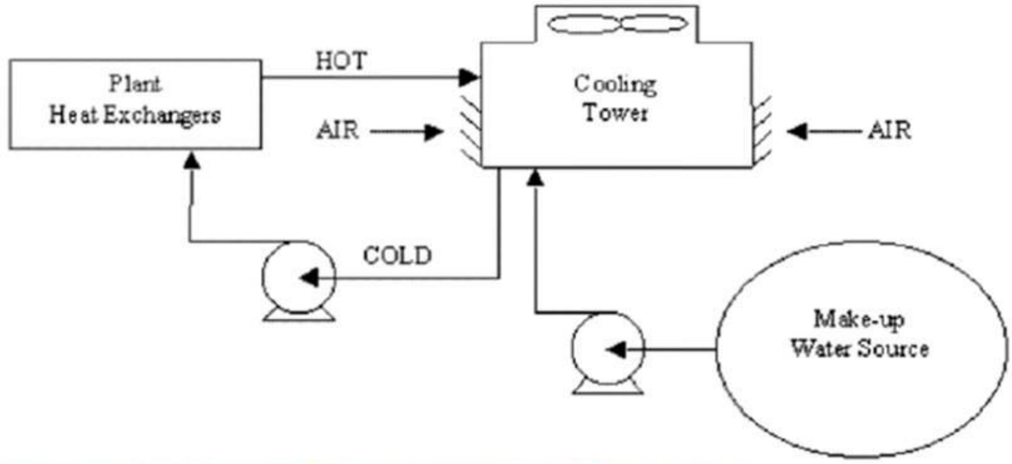
Cooling tower

- Primary task of cooling water is to reject heat into atmosphere.



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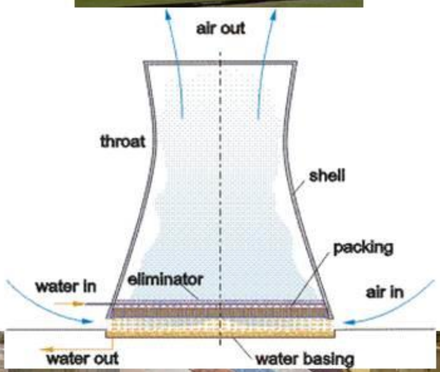
Natural draft cooling tower



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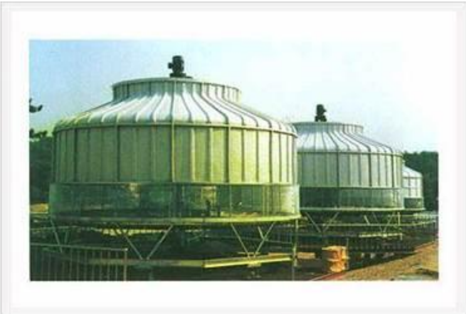
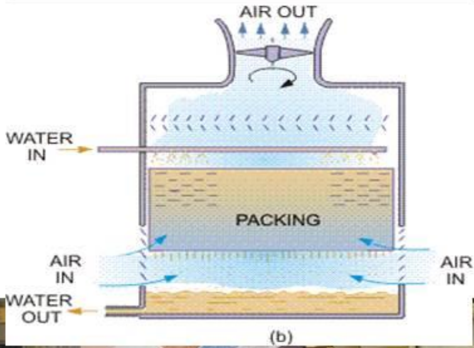
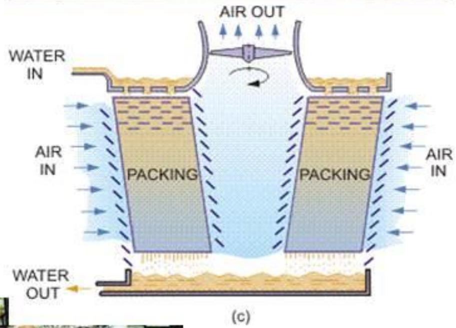
Forced draft cooling tower

Counter flow





Cross flow



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Important equations of cooling tower

- Cooling effect (kCal) = Flow of water x density x (T_i – T_o)
  - Flow of fluid/air in cubic meter per hour
  - Density in kg per cubic meter
  - T_i - Temperature of input water
  - T_o - Temperature of output water
- Cooling in TR = Cooling in kCal/3024
- Specific power consumption (kW/TR) = Power input / cooling effect

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Performance assessment of cooling tower

Step -3
Estimate monthly average DBT and WBT temperature from historical metrological data

Step -2
Identify material of construction of fan blade

Step -1
Log water temperature differential across cooling tower

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Delivered TR is less than design TR

Solutions

- Renovation of existing cooling tower by replacing choked fill material

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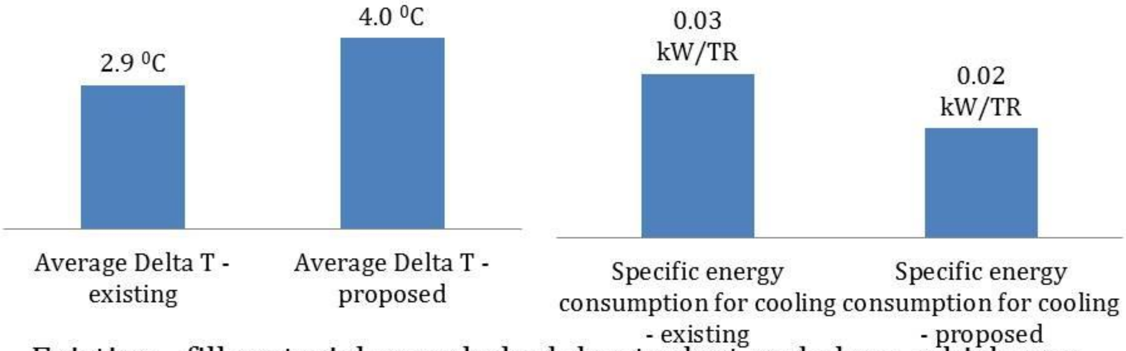
Renovation of existing cooling towers

11 cooling towers with choked fill material



- Existing - fill material was choked due to dust and algae, which was leading to poor delivery of cooling effect.
- Replace existing fill material with efficient and less choking fill material
- % energy saving is 33.3%, Annual electricity saving – 162,575kWh
- Annual monetary saving is Rs. 8.4 Lakhs, simple payback of 1.9 years

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CT fan has metallic blades

Solutions

- Replace with FRP blade fan

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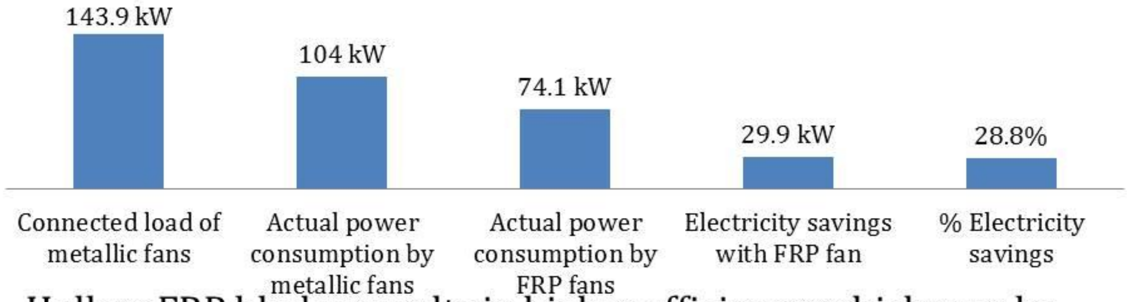
Installation of FRP blades in place of metallic blades

12 cooling towers with metallic blades at a large scale plastic plant



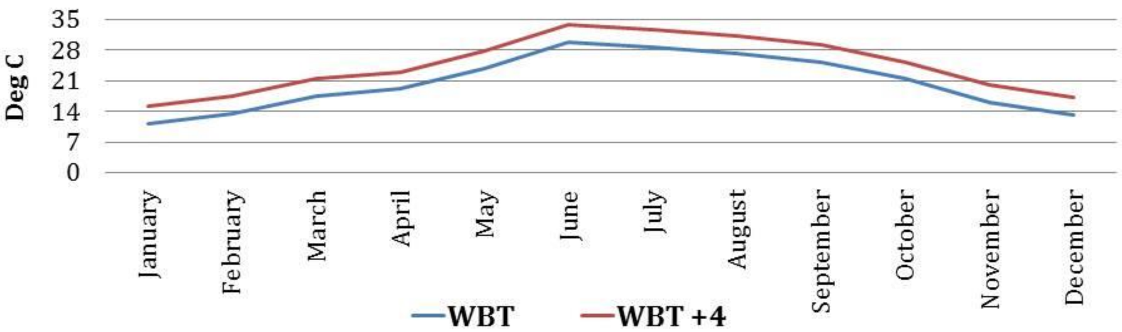
- Hollow FRP blades results in higher efficiency, which may be attributed to the special aerodynamic design, streamline finish and lightweight of blades. FRP blades are also corrosion free.
- Annual electricity saving – 250,900 kWh
- Annual monetary saving is Rs. 13 Lakhs with simple payback of 8 months

Load on cooling tower is variable

Solutions

- Install thermostatic controller or VFD on fan

Installation of Thermostatic controller on cooling tower fan



- For 7 months a year, WBT+4 ^{0}C is below 28 ^{0}C (temperature generally under which fan of cooling tower may be switched off).
- Present operating hours – 8,760 hours, proposed case – 6,205 hours.
- % electricity saving of 12.4%, annual electricity saving – 91,495 kWh
- Annual monetary savings of Rs. 4.8 Lakhs, simple payback of 6 months

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Thank you

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Potential of EE/RE Technologies in Ceramics Industry
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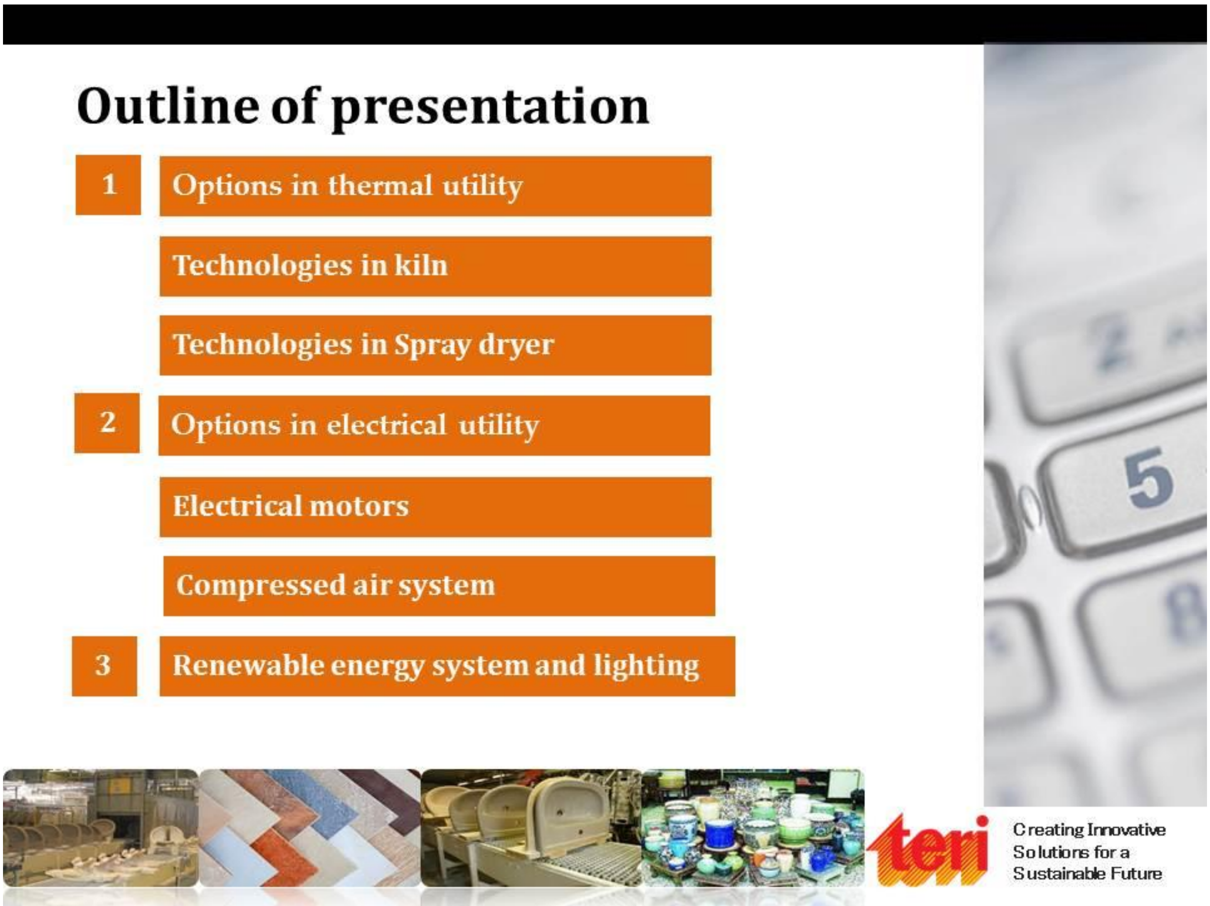
Outline of presentation
1
Options in thermal utility
Technologies in kiln
Technologies in Spray dryer
2
Options in electrical utility
Electrical motors
Compressed air system
3
Renewable energy system and lighting
Creating Innovative Solutions for a Sustainable Future

Technologies for Thermal utility

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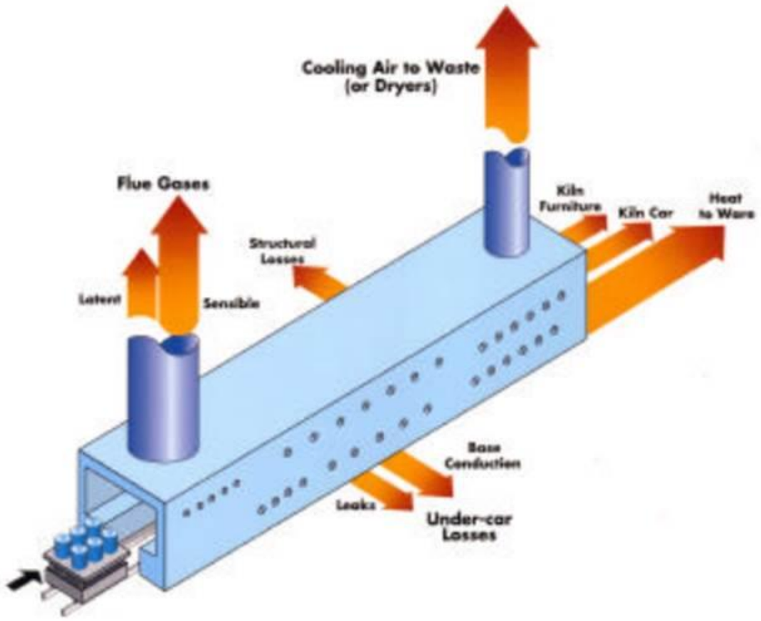
Kiln Energy Balance



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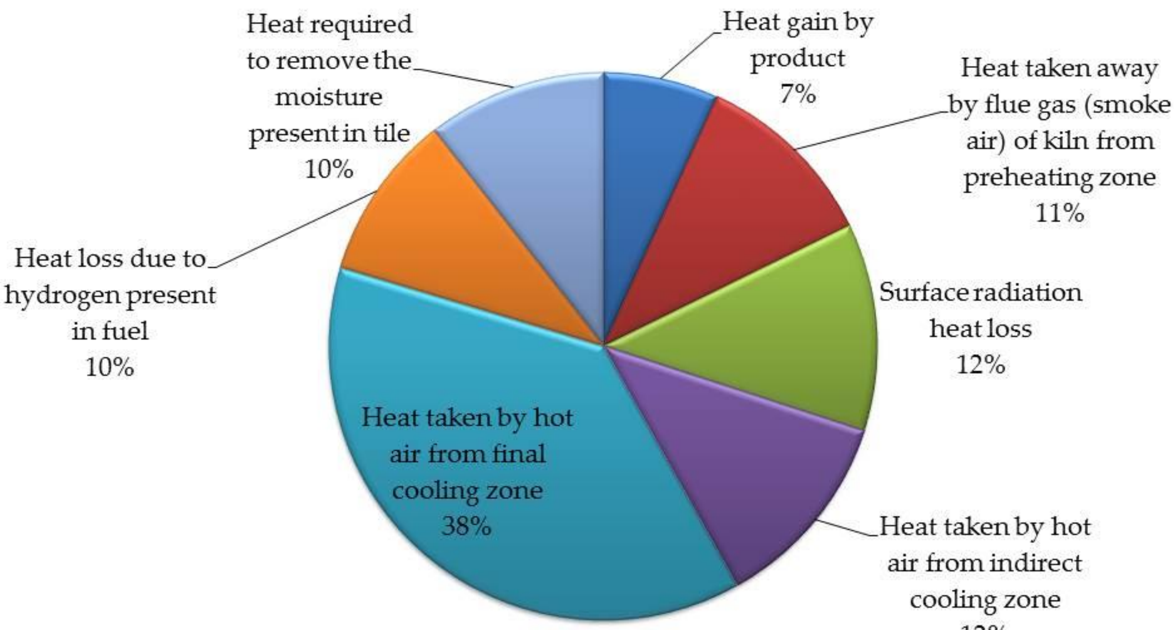

Thermal energy balance of a Kiln

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VARIOUS OPTION AND TECHNOLOGY AVAILABLE

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Main three components responsible for Energy efficiency in Kiln

- ✓ Design
- ✓ Material Movement
- ✓ Draft system

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Addition methods to achieve energy efficiency in kiln

- ✓ Energy management system and burners
- ✓ Integrated process control
- ✓ Internal heat re-use
- ✓ The development of low thermal mass (LTM) materials and ceramic fibers has improved kiln efficiency
- ✓ Minimizing non-payload throughput

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Technologies available

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Efficient combustion control or Burner management system

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Automatic combustion control system

- Benefits :
  - Better combustion efficiency
  - Reduces fuel consumption
  - Increases waste heat recovery potential
  - Reduces blower power consumption
  - Increase productivity

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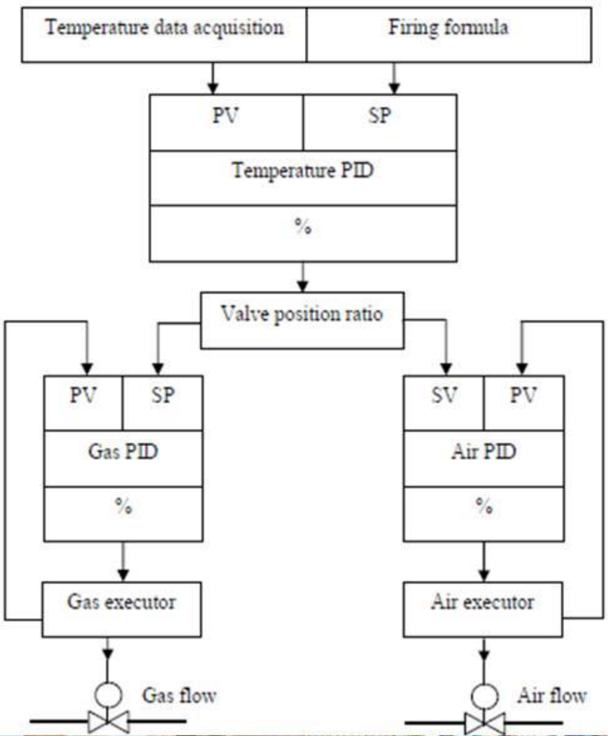
PID based combustion control



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Reduction of dead weight

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Principle

- Use of low thermal mass for kiln cart to **reduces the thermal weight** of the kiln considerably
- Weight reduction in kiln car saves significant amount of energy and also **improve material to car weight ratio**
- Reduces excess the **thermal energy storage** in the kiln furniture (**Roller**)

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Ways out and benefits

- Use of improved insulation material such as ultralite and hollow bricks
- Ultralite insulating material with supporting block gives proper support and increase the strength of the kiln base
- Replacing refactory bricks with hollow ceramic coated pipes at the supporting pillars for holding racks
- Dead weight can be cut down to 15 to 25% of the existing weight

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Low weight and density

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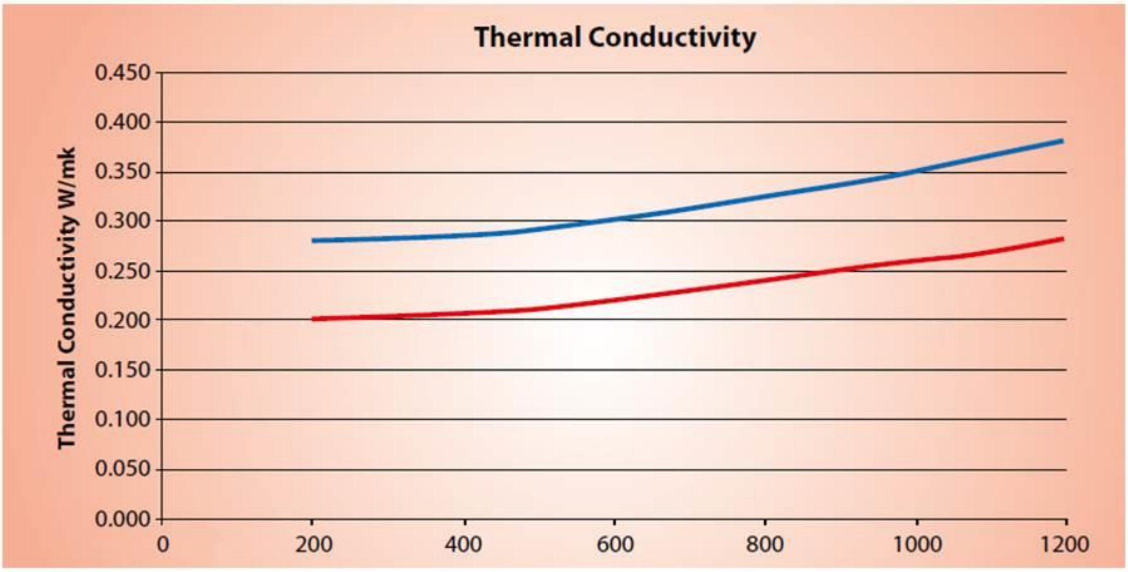
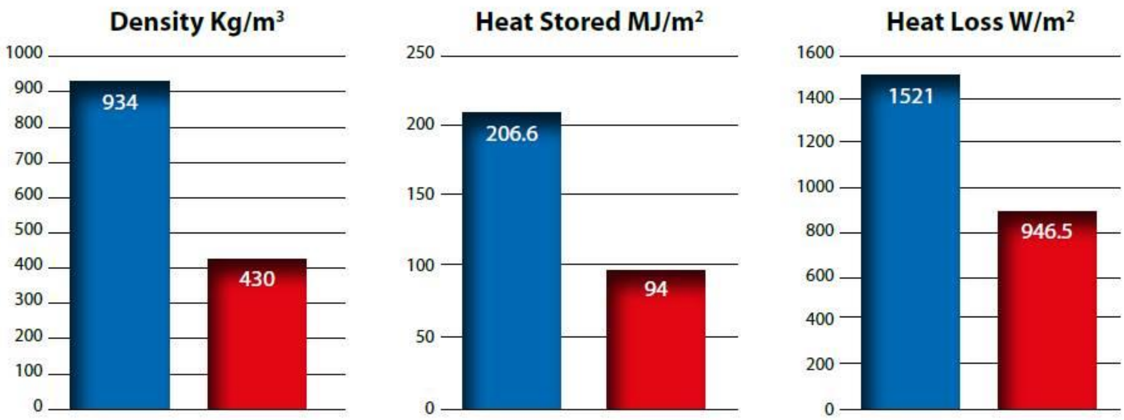
Low thermal conductivity



Less heat stored and lower loss



Advantages of Ultralite insulating material

- High open porosity
- Low thermal mass
- Low permeability
- Low thermal conductivity
- Low bulk density
- Lightweight

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Undercar Temperature Comparison	Traditional Construction	Ultralite Construction
Hot Face/Peak Firing Temperature (°C)	1250	1250
Undercar Temperature/Cold Face (°C)	111	97
	Undercar Temperature Saving ‡ 12%	

Heat Energy Comparison in Kiln Car Base	Traditional Construction	Ultralite Construction
Total Heat Flow (MJ)	170.1	137.9
Heat Stored (MJ)	433.7	206.7
Combined Heat in Kiln Car Base	603.8	344.6
	Energy Saving in Kiln Car Base Insulation ‡ 43%	

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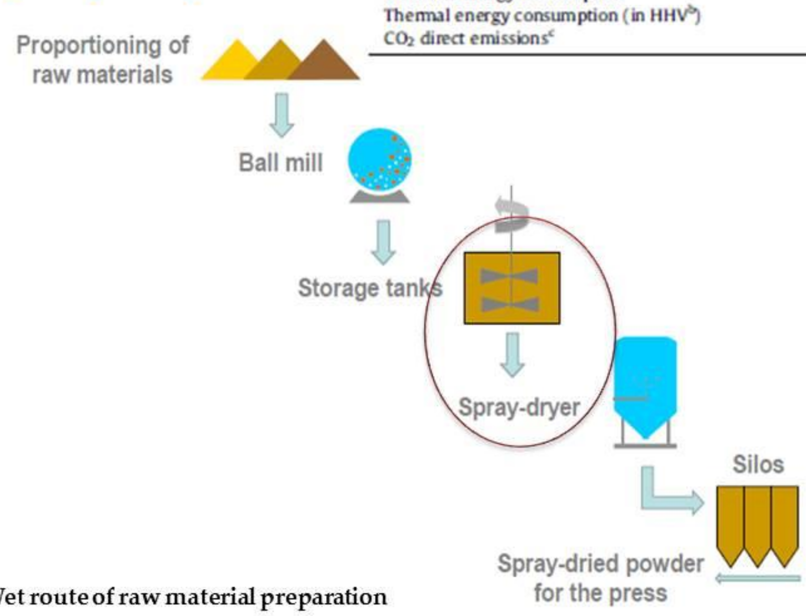
Spray dryer

Wet process	Consumption
Water consumption	0.47–0.59 m^3/Mg d.s.[a]
Electrical energy consumption	50–54 kWh/Mg d.s.
Thermal energy consumption (in HHV[b])	442–462 kWh/Mg d.s.
CO_2 direct emissions[c]	80–84 kg CO_2/Mg d.s.



Wet route of raw material preparation

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Efficient way of raw material preparation

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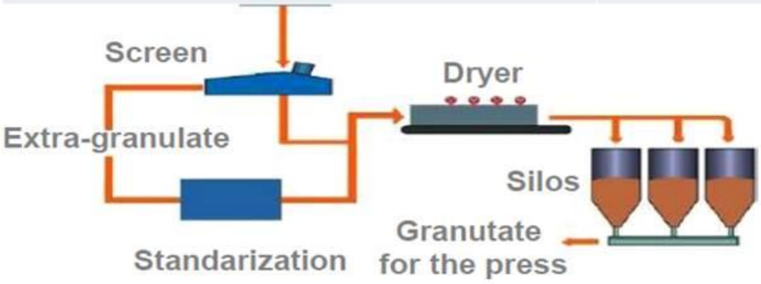
Dry route of raw material preparation

Parameters	Comparison of wet and dry basic
Water consumption	75% less than wet basis
Electrical Energy Consumption	30% less than wet basis
Thermal Energy Consumption	70% less than wet basis
CO2 direct emission	75% less than wet basis



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Energy efficient technologies in electrical system

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Electrical Utility

INDUCTION MOTORS AND ASSOCIATED AUXILIARIES

Why EE Motors

- More than 300 million motors are used in industry
- About 30 million new electric motors are sold each year for industrial purposes alone.
- Electric motor driven systems in industry are estimated to be responsible for 69% of industrial electricity consumption.
- Most of the motors installed in Indian industries are standard efficiency class (IE-1 or Non IE)
- Approximately 16% motors are rewinded multiple time

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Electric motor driven systems

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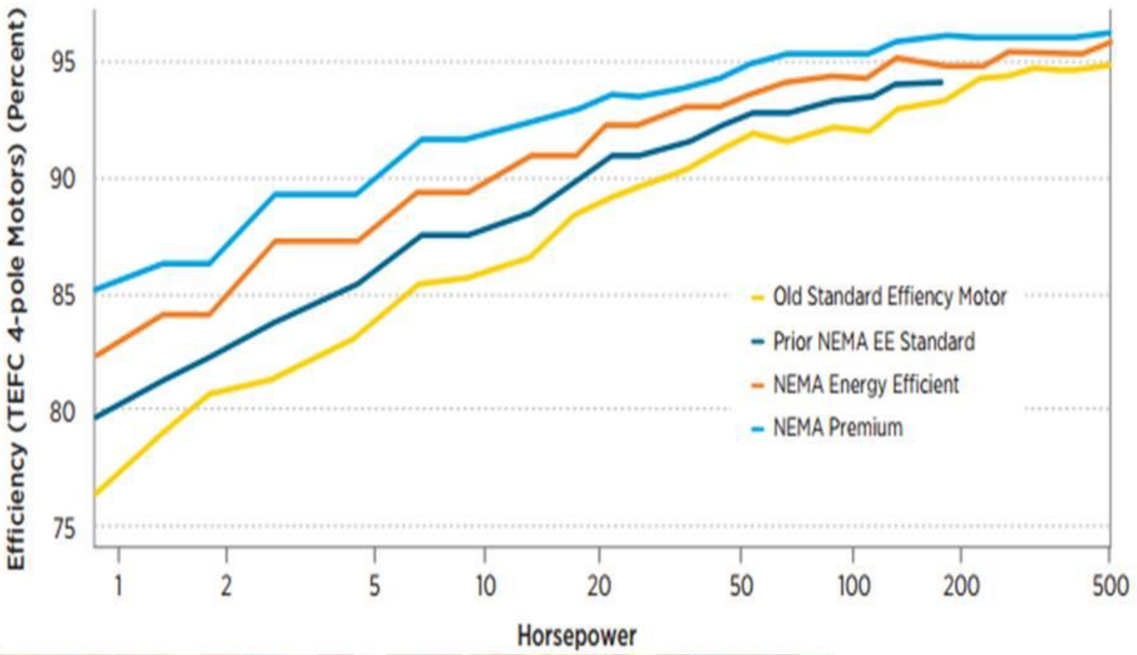
Premium Efficiency Class Motor (IE3)



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Motors Not Covered by IE3

- Single-phase motors
- DC motors
- Two-digit frames (48-56)
- Multi-speed motors
- Medium-voltage motors
- Totally enclosed nonventilated (TENV) and
- Totally enclosed air over (TEAO) enclosures
- Motors with customized OEM mountings
- Intermittent duty motors
- Submersible motors
- Encapsulated motors
- Motors that are integral with gearing or brake
- where the motor cannot be used separately
- Design D motors
- Partial motors

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Cost of operation – Life cycle costs

Description	Unit	IE1	IE2	IE3
Motor Load Requirement	kW	13.5	13.5	13.5
Motor Rating	kW	15	15	15
Motor Efficiency at operating load	%	88.7	90.6	91.4
Input Power	kW	15.2	14.9	14.8
Motor loading	%	90.0	90.0	90.0
Annual electricity consumption (@ 5000 hours per year)	kWh/Year	76,099	74,503	73,851
Difference in electricity consumption	kWh/Year	-	1,596	2,248
Increased in running (@ Rs. 6.5 per kWh)	Rs./Year	-	10,373	14,612
Initial investment	Rs.	25,500	29,950	31,875
Increase in Investment	Rs.	-	4,450	6,375
Lifecycle cost (@ 5 Years)	Rs.	24,98,724	24,51,308	24,32,039

Incremental cost of motor (IE3) will be recovered within 5 months.

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Variable loads and VFD or ASD

- Many motor applications have high operating hours but variable loads.
- VFD/AD helps in adapting motor speed and torque to the required load.
- Largest benefit comes with pumps & fans in closed loops for which power consumption varies as a cubic power of their rotational speed.
- In air-conditioning systems, the temperature and flow control of pumps and fans can be achieved with VSDs, reducing on/off cycles and providing a more stable indoor climate

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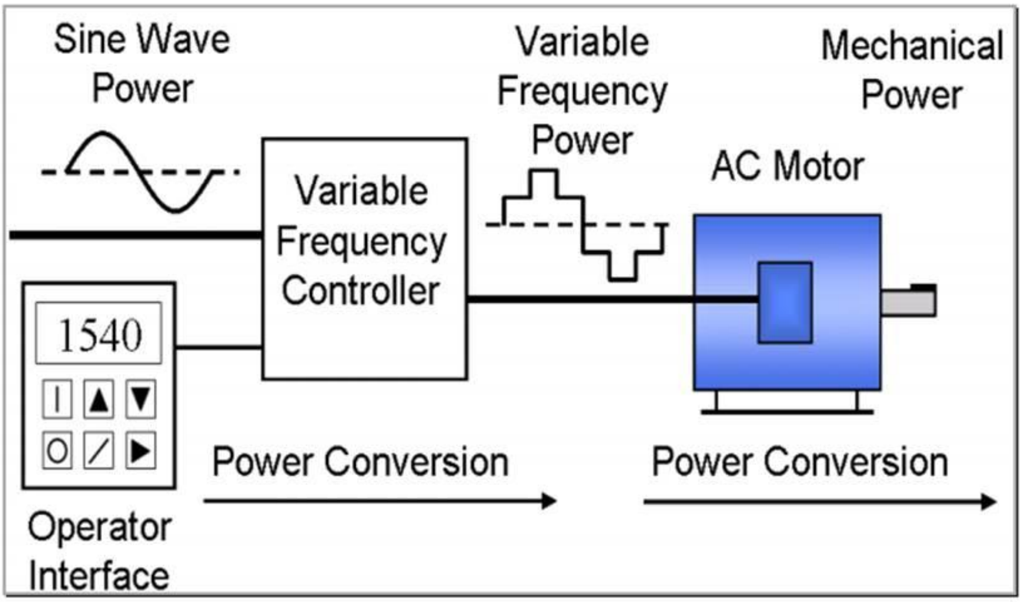
Schematic variable-frequency drive



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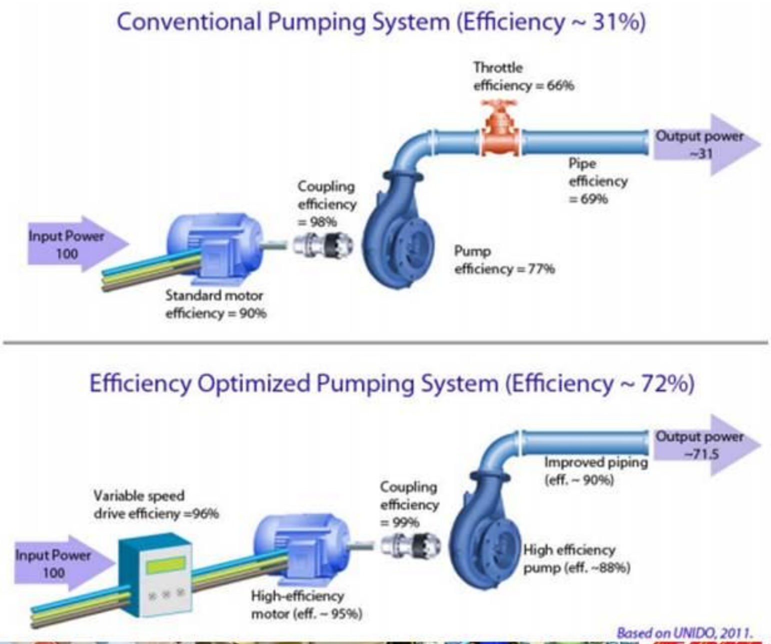
Application of VFD



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Gears and transmissions

- Gears are used in some applications to convert motor speed to the required speed.
- Some types of gears (worm gears with very high gear ratios) can be very inefficient
- Gear losses come from tooth friction and lubrication churning.
- Losses tend to be between 2% and 12% higher in new gears until the teeth are smoothed.
- High gear losses can be avoided by using a motor with a pole number and respective speed closer to the desired rpm of the driven equipment.
- If the gear is not used to provide maximum torque at low speed, a VFD can be used instead.

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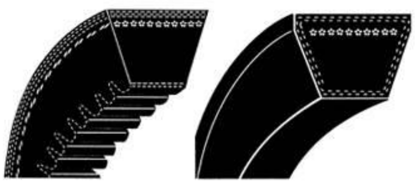
Gear efficiency

Gear type	Normal ratio range	Pitch line velocity (m/s)	Efficiency range
Spur	1:1 - 6:1	25	98% - 99%
Helical	1:1 - 10:1	50	98% - 99%
Double helical	1:1 - 15:1	150	98% - 99%
Bevel	1:1 - 4:1	20	98% - 99%
Worm	5:1 - 75:1	30	20% - 98%
Crossed helical	1:1 - 6:1	30	70% - 98%

Poly cogged belt

- V-belt drives can have a peak efficiency of 95% due to slippage occurance
- Poly cogged belt will have 98% peak efficiency due to less slippage compared to V-belt
- Also they run cooler and are durable hence last longer



Electrical Utility

AIR COMPRESSORS

Overview and Applications

- Compressors are used in the following three electric motor-system applications:
  - air compressors for compressed air,
  - liquid natural gas, gas transport, etc.;
  - cooling compressors; and heat pumps.
- Compressor technology uses reciprocating, rotary screw and centrifugal systems.
- Many compressor systems run in an efficiency range of only 5% to 10%

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Losses in a compressed-air system

Source of power loss	Transferred "useful" power (kW)	Power loss (kW)
Electrical power input	100	
Air from compressor	10	90 (heat)
Treatment	9	1 (*e.g.* filter pressure drop)
Leakage	6	3 (leakage)
Distribution system	5.5	0.5 (*e.g.* excess pressure drop)
Over-pressure	5.0	0.5 (heat)

Source: Falkner and Slade, 2009.

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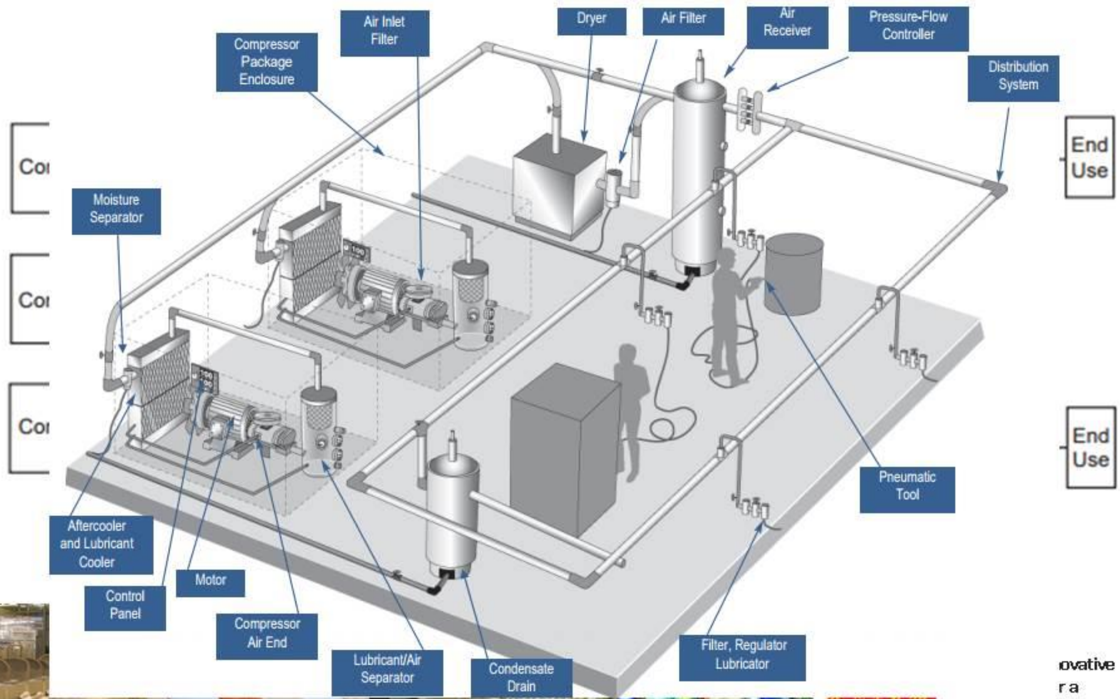
Simplified block diagram



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Rotary Compressors

- Compact size and complete package
- Economic first cost
- Vibration-free operation does not require special foundation
- Part-load capacity control systems can match system demand
- Suitable for variable speed control with improved performance at part load)
- Routine maintenance includes lubricant and filter changes.

Use of Variable frequency drives for screw air compressors

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Membrane-type dryers

- Low installation cost
- No electrical consumption
- Can be installed outdoors
- Can be used in hazardous atmospheres
- No moving parts

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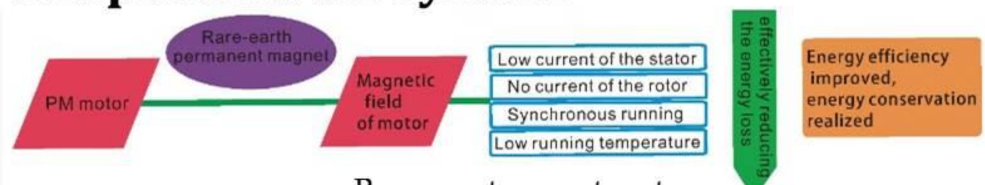
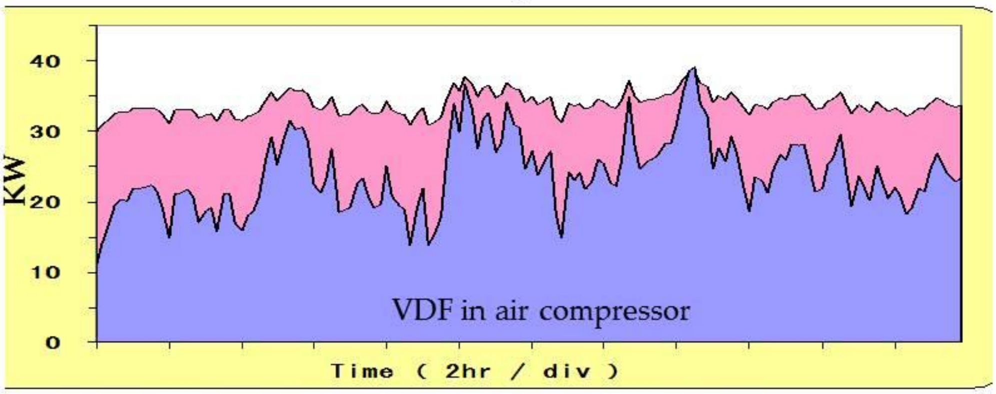
Ring loop air distribution piping

- Balanced air pressure in the plant
- Reduction in pressure loss
- Avoid underground air piping in the plant
- Tapping should always be taken from the top of the main header line
- Drainage points should be provided at the bottom of each tapping
- Automatic drain valve should be installed at the receiver for regular water drain from the tank
- Timer frequency should be changed as per the season, more frequent draining in the rainy season

VDF enabled Permanent motor driven compressed air system



Permanent magnet motor



VDF in air compressor

Air guns, spray guns/nozzles

Use of small diameter air guns, spray guns/nozzles

Arresting air leakages in air distribution system

- Use of crimped joints instead of clip joints
- Use of quick release coupling (QRC)

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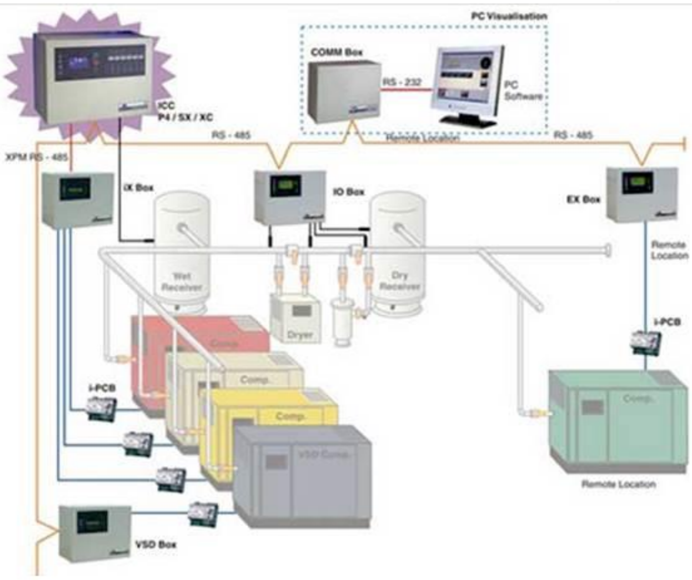
Compressed air management system



- Precise pressure regulation reduces the average system pressure output.
- Networked capacity control coordinates production among multiple compressors for maximum efficiency.
- Leak loss reduction is a byproduct of a lower average system pressure.
- Automated load scheduling can shut down or offload compressors when plant demand is lower.
- Proper intercooler control ensures better compressor efficiency.

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Seamless piping system

- Less fictional losses
- Lower head loss
- Less changes of leaks at the joints
- Higher life as compared to MS line

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Renewable energy options

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Solar roof top

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Nature has blessed with abundant lighting energy

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Do you really need Solar PV for lighting ???

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Solar tubes

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Energy Efficient Lighting system

Thank you

"The law of win/win says: Let's not do in your way or my way, let's do it the best way"

-Greg Anderson

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