Capacity Building workshop

Good practices in motor rewinding

13th February 2018 at Indore

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

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

Table of contents

Workshop summary

Overview of workshop

Capacity Building workshop of Local Service Providers (LSPs) on Good practices in motor rewinding & electrical maintenance was organized by TERI on 13th February 2018, Tuesday in association with IIF-Indore Chapter under GEF-UNIDO project. Total 28 participants were present during the workshop and for the institute/training centre visit, which was organized after the workshop. 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. C Harinarayan, Chairman, IIF-Indore Chapter welcomed the participants and thanked the team of TERI and UNIDO for arranging the capacity building workshop. He deliberated the necessity to conserve energy and mentioned that after melting, the second most energy consuming section in foundries is motors and motor driven system. He encouraged the motor rewinders and electricians to take the benefit of the training programme and support foundries and other units to maintain the optimum efficiency.

Mr Prabhat Sharma gave a brief background of the GEF-UNIDO-BEE project activities in Indore foundry 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.

Mr. Ayan Ganguly gave descriptive presentation on best operating practices in electric motor. He explained the primary reasons which may affect the operational efficiency of the motors and how to improve using good practices, which eventually results in significant amount of energy savings. He also shared various case studies on how to optimise the existing electric motors driven system. He explained about the energy efficient machines though required high capital cost can result in lower running cost over a lifetime due to its efficient operation.

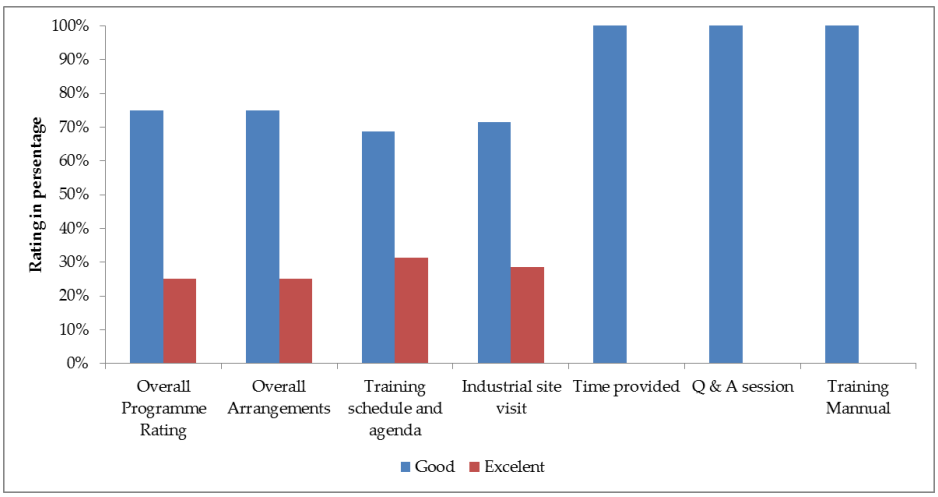
Mr. Pawan Tiwari gave presentation on the imperative practices to be adopted during repairing and rewinding of electric motors in order to maintain the efficiency close to design. He considered the material and machinery to be used to avoid the deterioration in efficiency after rewinding. This session of the training introduced the basic tools/machinery is to be used during the rewinding so that stator core and other sensitive parameters can be kept unaltered.

After the lunch, the participants were taken to electrical machine lab of Shri Vaishnav Polytechnic College, Indore to get hands on training on practical aspects of energy efficiency in electric motors and impact on efficiency after rewinding. Selected photos of the workshop and site visit are attached in the annexure 3.

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 70% participants were satisfied

with site visit, Q&A session and training module provided to them. About 75% participants have rated overall program as "good" while rest of them have rated it as "excellent". More than 75% of participants 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) Regular workshops on motor maintenance
2) Basic knowledge book on motor material rewinding materials

Learning's by participants

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

1) Calculation on motor performance
2) Day to day maintenance and preventive maintenance practices to be adopt
3) IE3 motors
4) Procurement of EE motors

Annexures

Annexure 1: Agenda of the program

Capacity building workshop

Good practices in motor rewinding & electrical maintenance

Tuesday, 13 February 2018

Jash Engineering, 31, Sector C, Industrial Area, Sanwer Road, Indore

Under the project:

Capacity Building of Local Service Providers (LSPs)

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Agenda

10:00 – 10:30	**Registration**
10:30 – 10:40	**Welcome Address** Mr C Harinarayan, Chairman, IIF-Indore Chapter
10:40 – 10:50	**GEF-UNIDO-BEE project and initiatives in Indore cluster** Mr Prabhat Sharma, UNIDO Cluster Leader - Indore
10:50 – 11:50	**Assessment of energy efficiency and energy efficiency improvement opportunities in induction motors** Mr Ayan Ganguly, TERI
11:50 – 12:50	**Operation, maintenance and rewinding practices of induction motors** Mr Pawan Tiwari, TERI
12.45 – 13:00	**Q&A**
13:00 – 14:00	Lunch
14:00 – 16:00	**Site Visit / On-site training** Visit to Shri Vaishnav Polytechnic College, Indore
16.00 – 16:30	Feedback from participants
16:30 – 16:45	**Vote of thanks**

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Annexure 2: List of participants

S. No	Name	Organization	Mobile No	Email ID
1.	Shirish Khadre	Mahle Engine Components India Pvt. Ltd	9977054868	Maintenance.mscs@in.mahle.com
2.	Bhawan Parihar	Mahle Engine Components India Pvt. Ltd	9179829982	Maintenance.mscs@in.mahle.co.in
3.	Ajay Patel	Porwal Auto Comp. Ltd	9647027003	
4.	Neeraj Kumar	Porwal Auto Comp. Ltd	9630451386	Maintenance@porwalauto.com
5.	Rajdeo Sah	Infile Solution, Indore	9583182981	rajdeo@infilesolution.org
6.	Lokender Baurasi	Pioneer Ujjain	9827284711	
7.	Safder Hussain	Motor rewinder (LSP)	9826457198	
8.	Anil	Good Luck Automobile	9926895002	
9.	Anand Guaja	Jash Engg. Ltd	9754193432	anandgaugar@gmail.com
10.	Shailendra Singh	Jash Engg Ltd	9039604282	Shails.rajput@gmail.com
11.	Sunil Jadav	Combined Engg. Pvt Ltd	9617369921	Sn.jadhav1981@adikmail.com
12.	A N Pandey	Pioneer Engineering Ujjain	7389941905	Anpandey1963@gmail.com
13.	Anil Dwavale	Ex CL Indore Cluster	9644400045	Anil181818@gmail.com
14.	Hariom	Mangla Engineering	9893273237	
15.	Narendra Singh	Mangla Engineering	8818881893	Narendra_shnre@manglaengg.com
16.	Sangram Patil	Jash Engineering Ltd	7869962233	sangam@jashindia.com
17.	M K Gupta	Jash Engg Ltd	9755599655	maintenance@jashindia.com
18.	Atin Jain	Porwal Auto Components Ltd	9826570094	
19.	L D Amin	Jash Engg. Ltd	9755416000	ida@jashindia.com
20.	Hari Narayan	Pioneer Engg, Ujjain		
21.	Prem M	Ravina Power	9822089225	
22.	Mo Umar	Rinew Electric Work	9300702505	
23.	Mujahid Khan	Rinew Electric Work	9827219232	
24.	N Garg	N G Enterprise	9827033041	
25.	Nizam Khan	Star Electrical	8965815715	United.khan786@gmail.com
26.	Chandrakant Naobode	Bombay Electric & Engg Works	9039266571	Bombayelectric&enggworks@gmail.com
27.	Moinuddin	M P Electricals	9303229286	
28.	Nandan Garg	Nandan Enterprises	9630055541	nandanenterprisesindore@gmail.com

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Capacity building workshop

Good practices in motor rewinding & electrical maintenance

13 February 2018, Jash Engineering, 31, Sector C, Industrial Area, Sanwer Road, Indore

S. No	Name	Organization	Mobile No	Email ID	Signature
1.	Shirish Khadse	Mahle Engine Components India Pvt. Ltd.	9977034868	maintenance.mscs@in.mahle.com	
2.	Mr. Bhawan Parihar	Mahle Engine Components India Pvt. Ltd.	9179829982	maintenance.mscs@in.mahle.com	
3.	Mr. Ajay Patel	Parwal Auto Comp Ltd.	9644027003		
4.	Mr. Neeraj Kumar	Parwal Auto Comp Ltd.	9630451386	maintenance@parwalautocomp.com	
5.	Rajeev Sah	Infile Solutions, Indore	9583182981	rajeev@infilesolutions.org	
6.	लोकेन्द्र लौरासी	पायोनियर इंजीनियर	98272-84711		
7.			98264 57198		

S. No	Name	Organization	Mobile No	Email ID	Signature
8.	[illegible]	[illegible]	9926895002		
9.	Anand Gurjar	Jash Engg. Ltd.	9754193432	anandgurjar@gmail.com	
10.	Shailendra Singh	JASH ENGG. LTD.	9039604282	shails.rajput@gmail.com	
11.	Sunil Jadhav	Combined Engg. PVT LTD	9617869921	sn_jadhav1981@rediffmail.com	
12.	A.N. Pandey	Pioneer Engg Ujjain	7389941905	an pandey 1963@gmail.com	
13.	ANIL DHAVALE	EX CL Indore Cluster	9644400045	anil 18 18 18@gmail.com	
14.	Thakur	Mangla Engg	9893273237		
15.	Narendra Singh.	Mangla Engg., Devas	8818881893	narendra_shine@manglaengg.com	
16.	Sangram Patil	Jash Engineering Ltd	7869962233	sangram@jashindia.com	
17.	M.K. Gupta	Jash Engg Ltd.	9755599655	maintenance@jashindia.com	

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19	L. D. Amin	Jash Engg. Ltd.	97554 16000	lda@jashindia.com	
20	Harinarayan	Pioneer Engg. Ujjain			
21	prem Mishra	Ravina power	9822089135		
22	Mo. UMAR.	Rineu. Electric. Work	9200702505		
23	Mujahid Kha—	Rineu Electric Work.	98272.19232		
24	N. Garg	N. G. Enterprise	98270/33041		
25	NIZAM KHAN	STAR ELECTRICAL	8965857[illegible]5	UNITED.KHAN 7860@GMAIL.COM	
26	Chandrakant Naobade	Bombay Electric & Engg Works	9039266571	bombay Electric & Engg works @ gmail.com	
27	मोइनुद्दीन	सी पी. इलेक्ट्रिकल	9303229286		Moin

S. No	Name	Organization	Mobile No	Email ID	Signature
28	Nandan Garg	Nandan Enterprises	96300-5541	nandanenterprisesindore@gmail.com	
29					
30					
31					
32					
33					
34					
35					
36					
37					

Annexure 3: Selected photographs of the event

Annexure 4: Sample feedback forms

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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:			
Basic knowledge book on gauge and Rewinding for EE motor's Parameter.			
Name two learning, which from this programme you will be able to implement in your plant?			
Signature:	मुजाहिद		
Name of participant:	मुजाहिद खान		
Organization:	[illegible]		
Mobile No:	98272 19232		
Email ID:			

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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:			
Pl. plan energy saving training programe in Pithampur Area			
Name two learning, which from this programme you will be able to implement in your plant?			
Improve motor efficiency with Predtric maint.			
Signature:			
Name of participant: Shirish Khadse			
Organization: Mahle Engine Component India Pvt Ltd.			
Mobile No: 9977054868			
Email ID: maintenance.MSCS@in.mahle.com			

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How was the industrial site visit?	✓		
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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:			
Pls arrange and informs for other training venue for the organization in Mahle Engine Comp. Ind. Pvt. Ltd.			
Name two learning, which from this programme you will be able to implement in your plant?			
Training are full of technology of energy efficiency aspects and to be planned to taken benefits in machine shops to effective uses of motor or electrical equipments.			
Signature:			
Name of participant:	Mr. Bhawan Parihar		
Organization:	Mahle Engine Component Ind. Pvt. Ltd.		
Mobile No:	9179829582		
Email ID:	maintenance.mecs@in.mahle.com, erbhawan@gmail.com.		

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How was the industrial site visit?	✓		
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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:			
More Seminars with Workfree for Industry will be more useful.			
Name two learning, which from this programme you will be able to implement in your plant?			
1) Procurement of Motor			
2) Pred. Maint			
Signature:	Rajlesh		
Name of participant:	RAJLESH JAIN		
Organization:	Infinite Solutions, Indore		
Mobile No:	9583182981		
Email ID:	Rajlesh@infinitesolutions.org		

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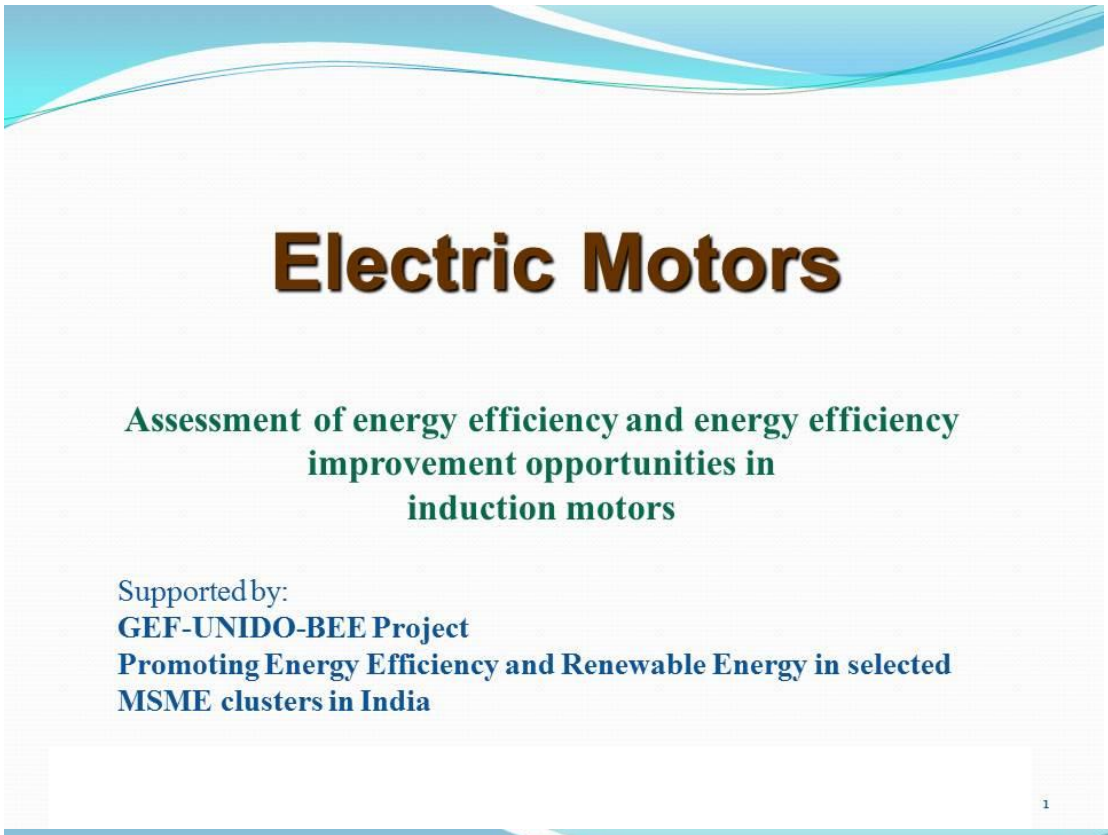
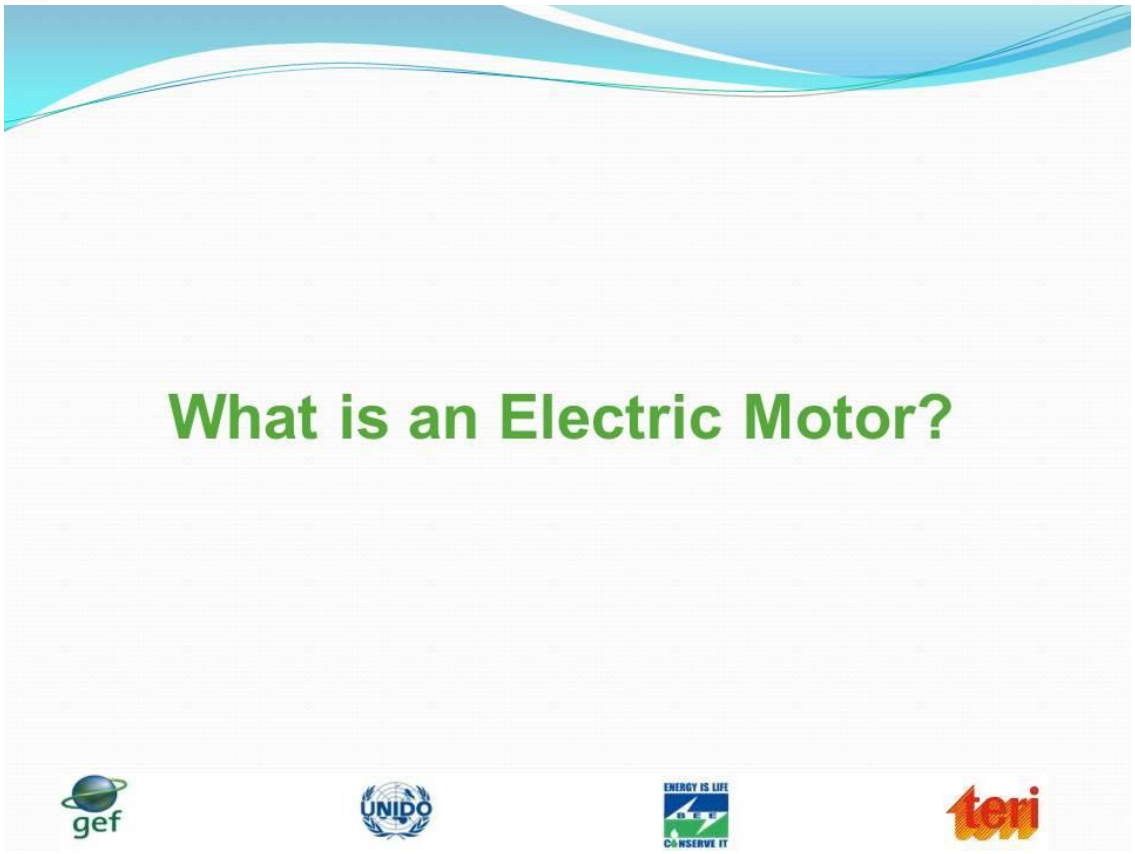
Annexure 5: Copy of presentations

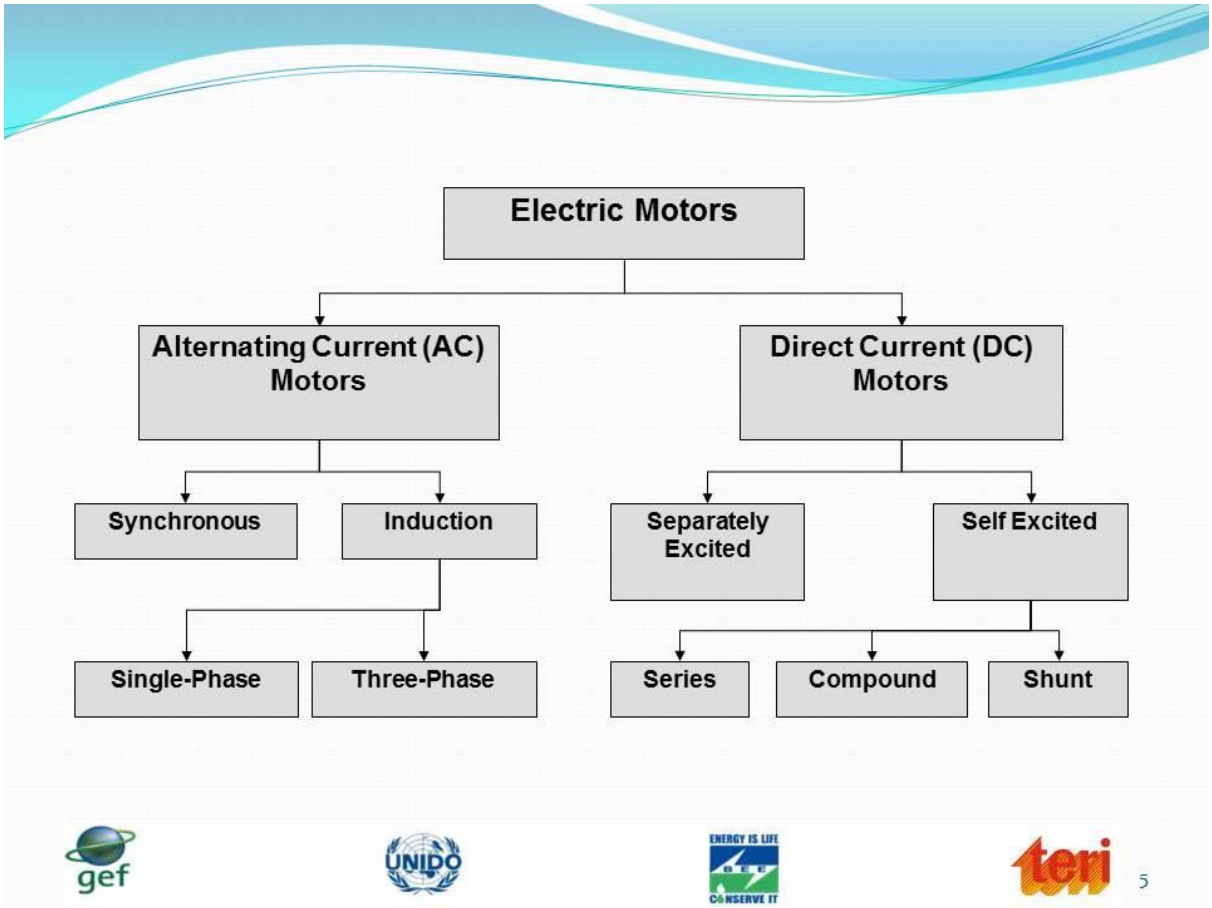




- **Electromechanical device that converts electrical energy to mechanical energy**
- **Mechanical energy used to e.g.**
  - **Rotate pump impeller, fan, blower**
  - **Drive compressors**
  - **Lift materials**
- **Motors in industry: 70% of electrical load**

3

What are the type of Electric Motors


Electric Motors
Alternating Current (AC) Motors
Direct Current (DC) Motors
Synchronous
Induction
Separately Excited
Self Excited
Single-Phase
Three-Phase
Series
Compound
Shunt
5


AC Motors

- Electrical current reverses direction
- Two parts: stator and rotor
  - Stator: stationary electrical component
  - Rotor: rotates the motor shaft
- Speed control is difficult
- Two types
  - Synchronous motor
  - Induction motor

7

Synchronous motor

- Constant speed fixed by system frequency
- DC for excitation and low starting torque: suited for low load applications
- Can improve power factor: suited for high electricity use systems
- Synchronous speed (Ns):

$$Ns = 120\ f / P$$

F = supply frequency
P = number of poles

8

Induction motor

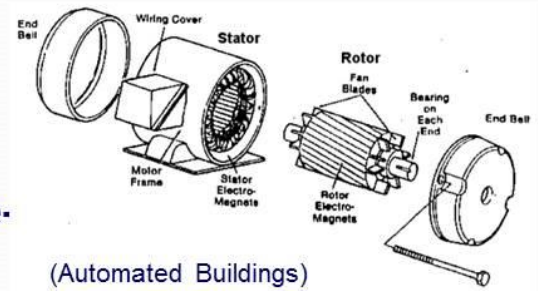
- Most common motors in industry
- Advantages:
  - Simple design
  - Inexpensive
  - High power to weight ratio
  - Easy to maintain
  - Direct connection to AC power source

Types of – Induction motor

- Single-phase induction motor
  - One stator winding
  - Single-phase power supply
  - Squirrel cage rotor
  - Require device to start motor
  - 3 to 4 HP applications
  - Household appliances: fans, washing machines, dryers
- Three-phase induction motor
  - Three-phase supply produces magnetic field
  - Squirrel cage or wound rotor
  - Self-starting
  - High power capabilities
  - 1/3 to hundreds HP applications: pumps, compressors, conveyor belts, grinders
  - 70% of motors in industry!

Components– Induction motor

- **Rotor**
  - Squirrel cage: conducting bars in parallel slots
  - Wound rotor: 3-phase, double-distributed winding



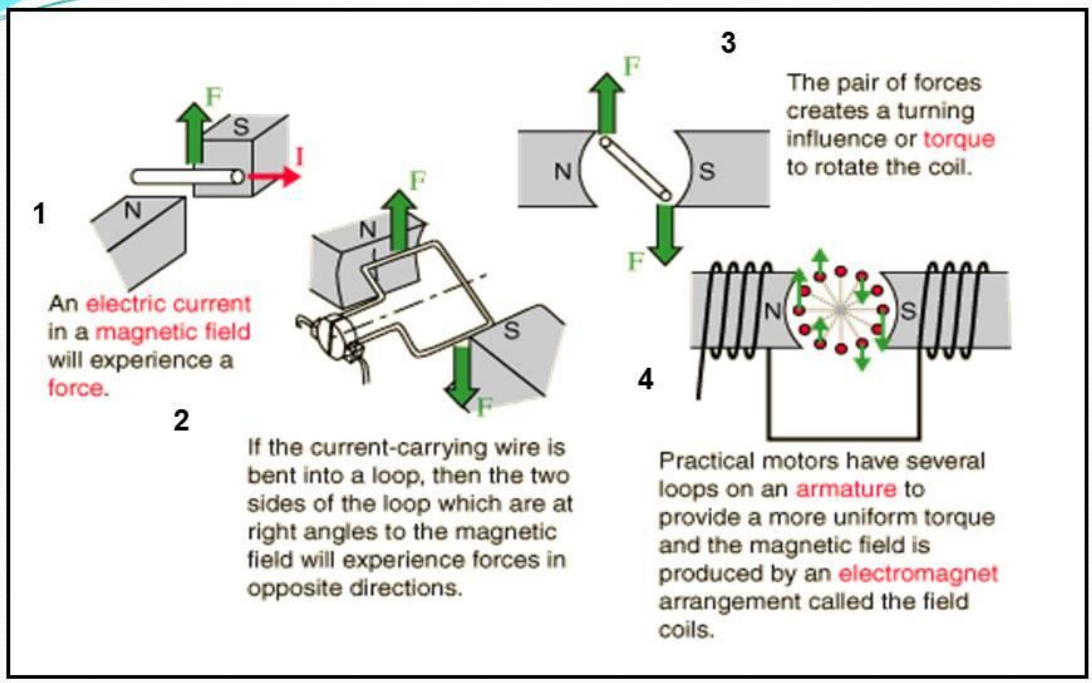
(Automated Buildings)

- **Stator**
  - Stampings with slots to carry 3-phase windings
  - Wound for definite number of poles

11

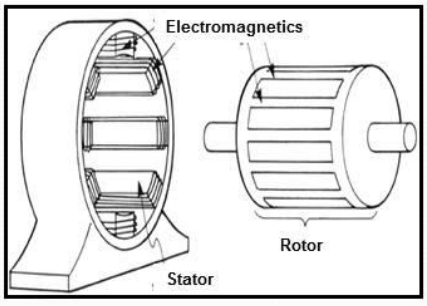
How Does an Electric Motor Work?

12

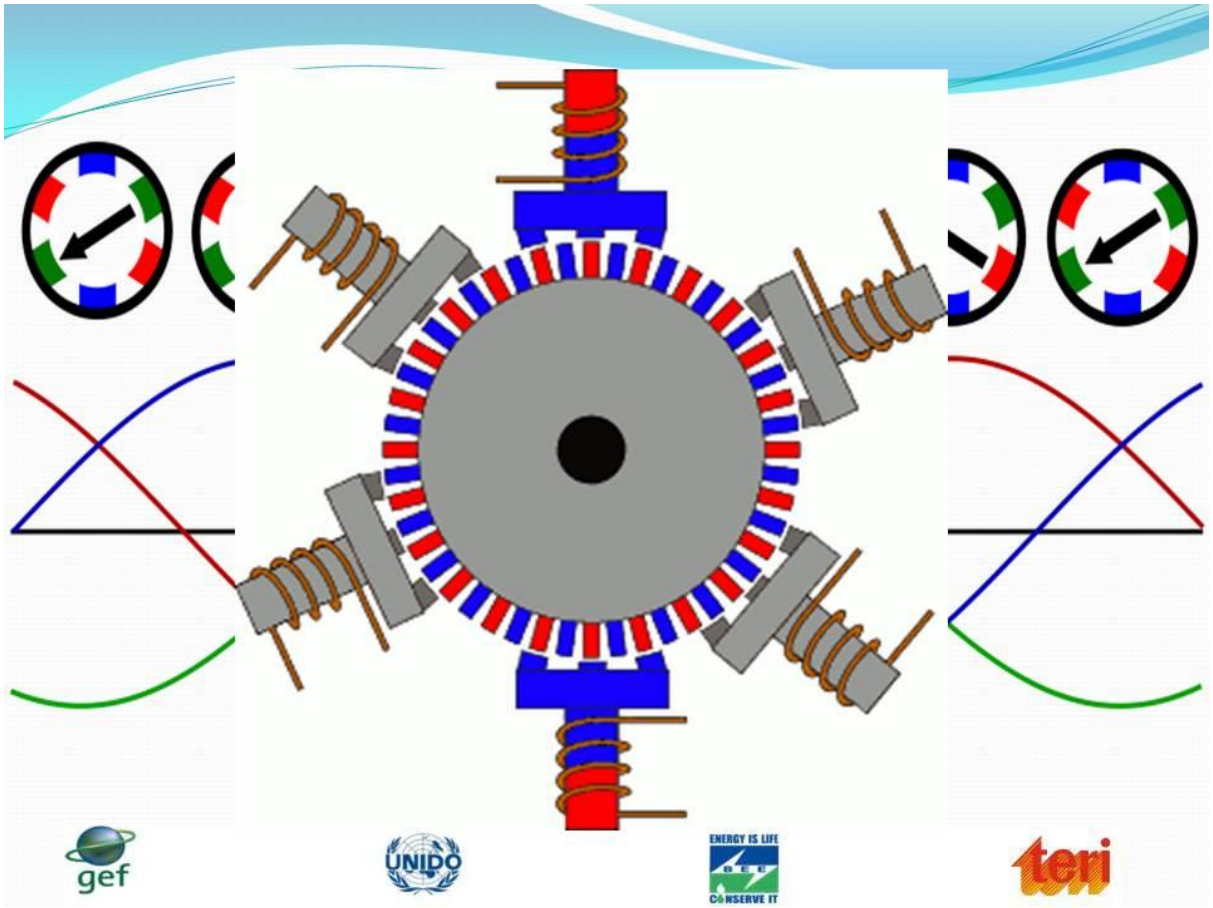


- Electricity supplied to stator
- Magnetic field generated that moves around rotor
- Current induced in rotor

- Rotor produces second magnetic field that opposes stator magnetic field
- Rotor begins to rotate



14



AC Motors – Induction motor

Speed and slip

- Motor never runs at synchronous speed but lower "base speed"
- Difference is "slip"
- Install slip ring to avoid this
- Calculate % slip:

$$\% \text{ Slip} = \frac{Ns - Nb}{Ns} \times 100$$

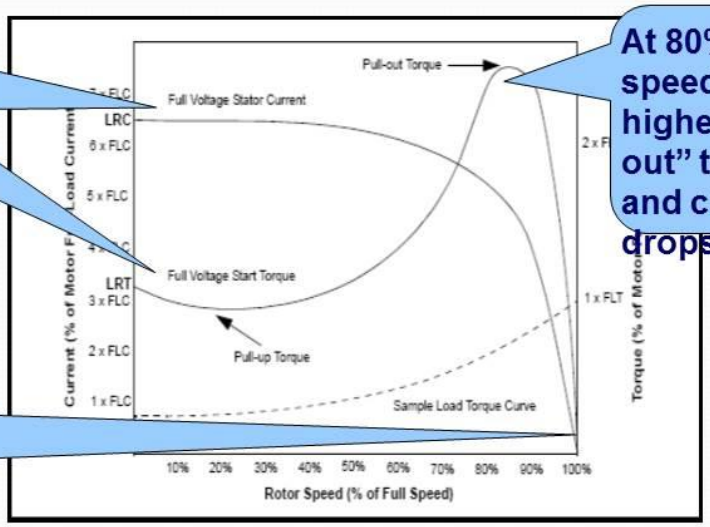
Ns = synchronous speed in RPM
Nb = base speed in RPM

Relationship load, speed and torque

At start: high current and low "pull-up" torque

At full speed: torque and stator current are zero

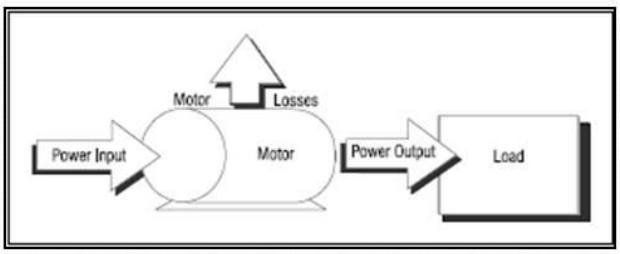
At 80% of full speed: highest "pull-out" torque and current drops

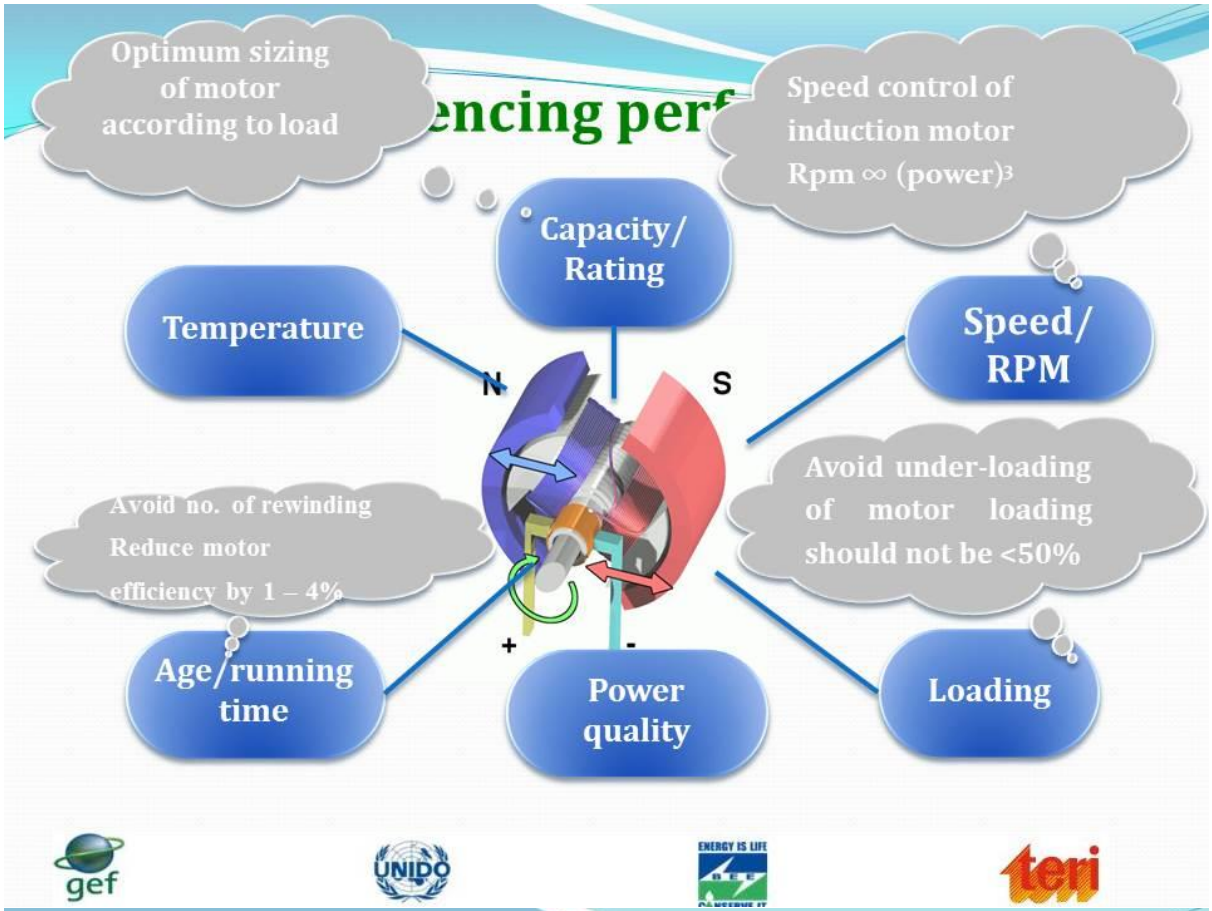


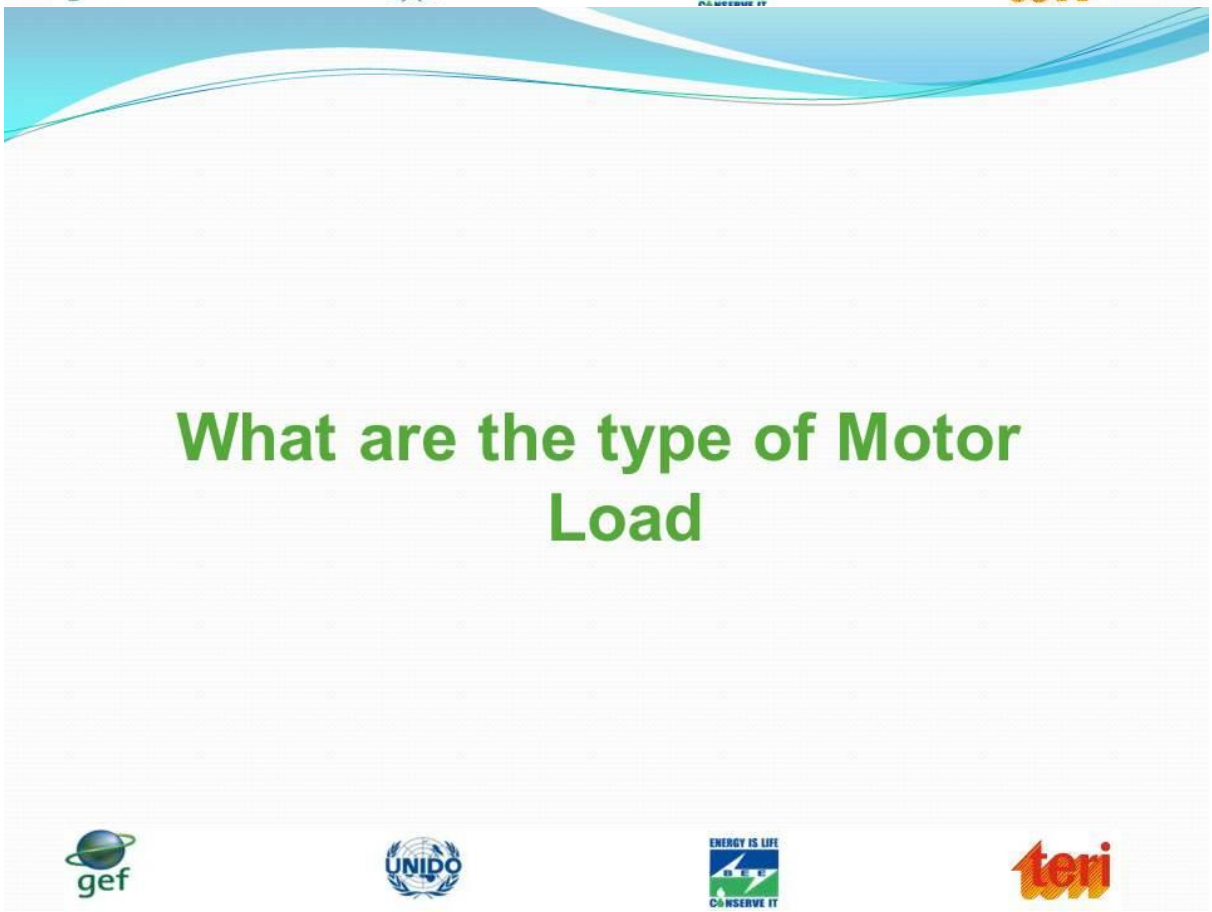
Efficiency of Electric Motors

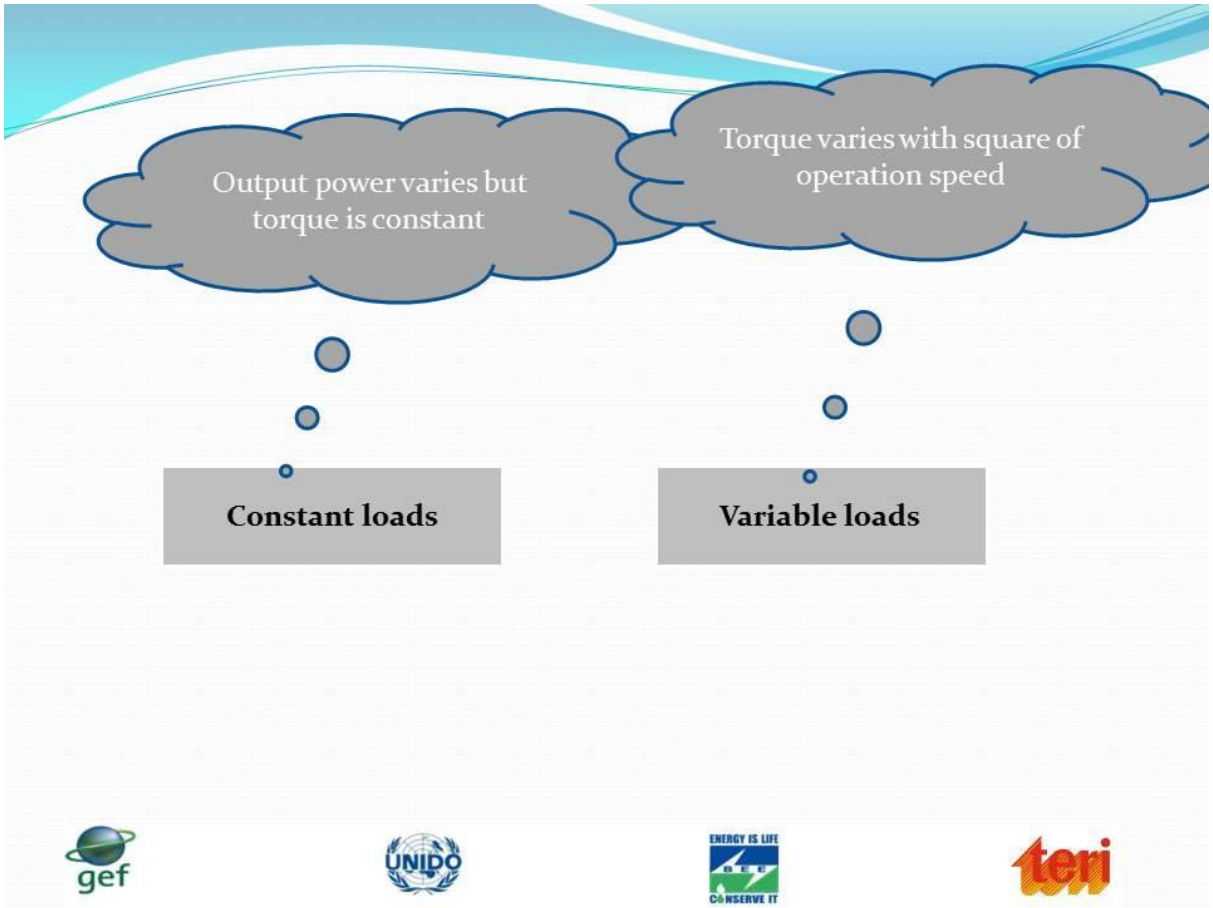
Motors loose energy when serving a load

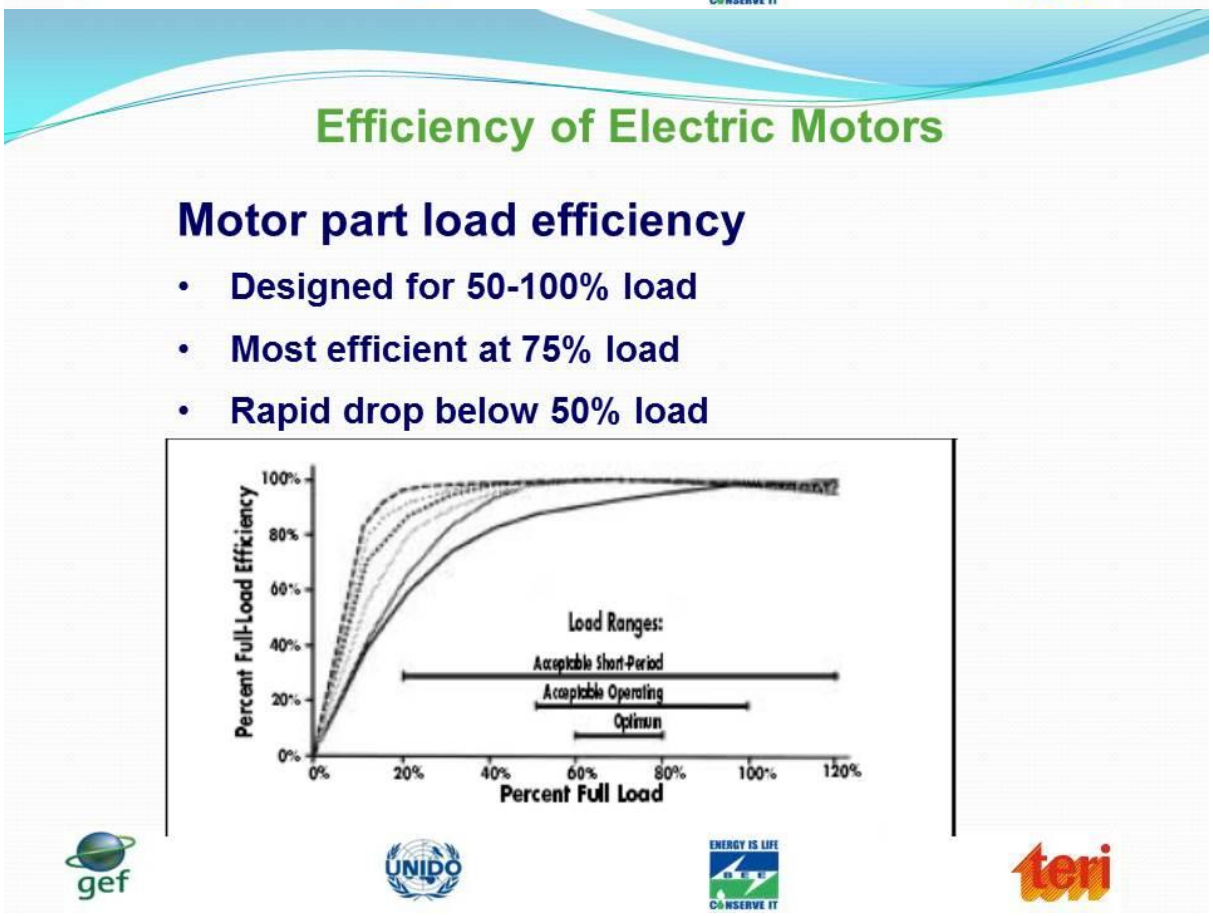
- Fixed loss
- Rotor loss
- Stator loss
- Friction and rewinding
- Stray load loss




Optimum sizing of motor according to load
encing perf
Speed control of induction motor Rpm ∞ (power)3
Capacity/ Rating
Temperature
Speed/ RPM
N
S
Avoid under-loading of motor loading should not be <50%
Avoid no. of rewinding Reduce motor efficiency by 1 – 4%
Age/running time
Power quality
Loading
+
-
gef
UNIDO
ENERGY IS LIFE
teri


What are the type of Motor Load
gef
UNIDO
ENERGY IS LIFE
teri


Output power varies but torque is constant
Torque varies with square of operation speed
Constant loads
Variable loads


Efficiency of Electric Motors
Motor part load efficiency
• Designed for 50-100% load
• Most efficient at 75% load
• Rapid drop below 50% load
Percent Full-Load Efficiency
100%
80%
60%
40%
20%
0%
Load Ranges:
Acceptable Short-Period
Acceptable Operating
Optimum
0%
20%
40%
60%
80%
100%
120%
Percent Full Load

Motor Load

- **Motor load is indicator of efficiency**
- **Equation to determine load:**

$$\text{Load} = \frac{Pi \times \eta}{HP \times 0.7457}$$

η = Motor operating efficiency in %
HP = Nameplate rated horse power
Load = Output power as a % of rated power
Pi = Three phase power in kW

Motor Load calculation

Three methods for individual motors

- **Input power measurement**
  - **Ratio input power and rate power at 100% loading**
- **Line current measurement**
  - **Compare measured amperage with rated amperage**
- **Slip method**
  - **Compare slip at operation with slip at full load**

Steps of Motor Load assessment

Input power measurement

- **Three steps for three-phase motors**

Step 1. Determine the input power:

$$Pi = \frac{V \; x \; I \; x \; PF \; x \; \sqrt{3}}{1000}$$

Pi	= Three Phase power in kW
V	= RMS Voltage, mean line to line of 3 Phases
I	= RMS Current, mean of 3 phases
PF	= Power factor as Decimal

Input power measurement

Step 2. Determine the rated power:

$$P_r = hp \; x \; \frac{0.7457}{\eta_r}$$

Pr	= Input Power at Full Rated load in kW
hp	= Name plate Rated Horse Power
ηr	= Efficiency at Full Rated Load

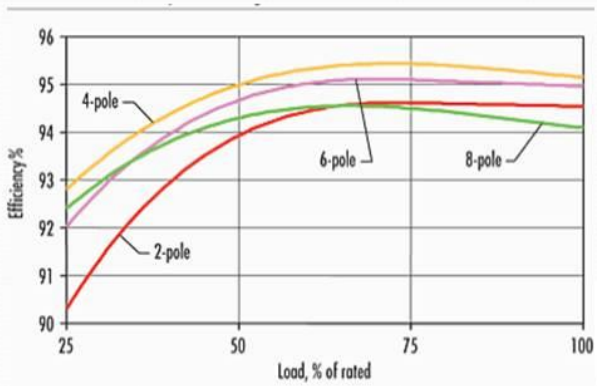
Step 3. Determine the percentage load:

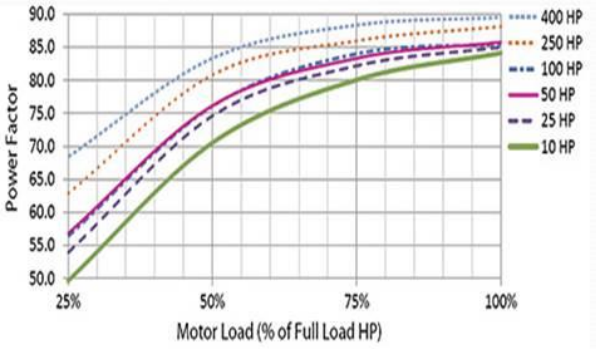
$$Load = \frac{Pi}{P_r} \; x \; 100\%$$

Load	= Output Power as a % of Rated Power
Pi	= Measured Three Phase power in kW
Pr	= Input Power at Full Rated load in kW

Energy efficiency opportunities in motors

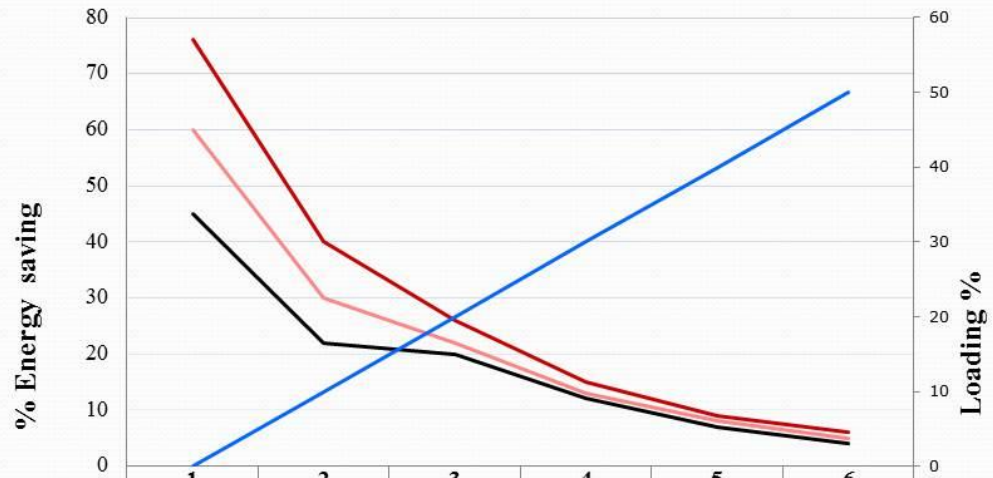
Avoid under-loading of motor





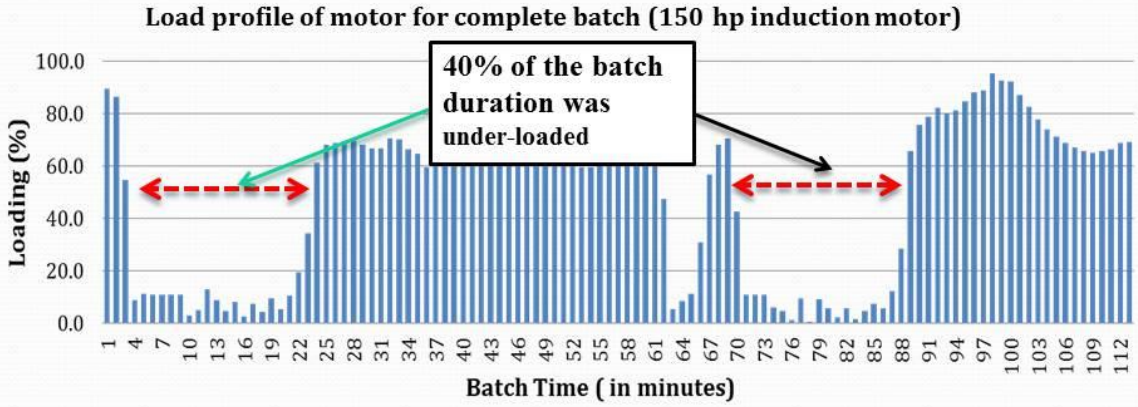
- ✓ **Efficiency and power factor drastically fall down as the loading decreases below 50%**

Use of Star delta Convertor



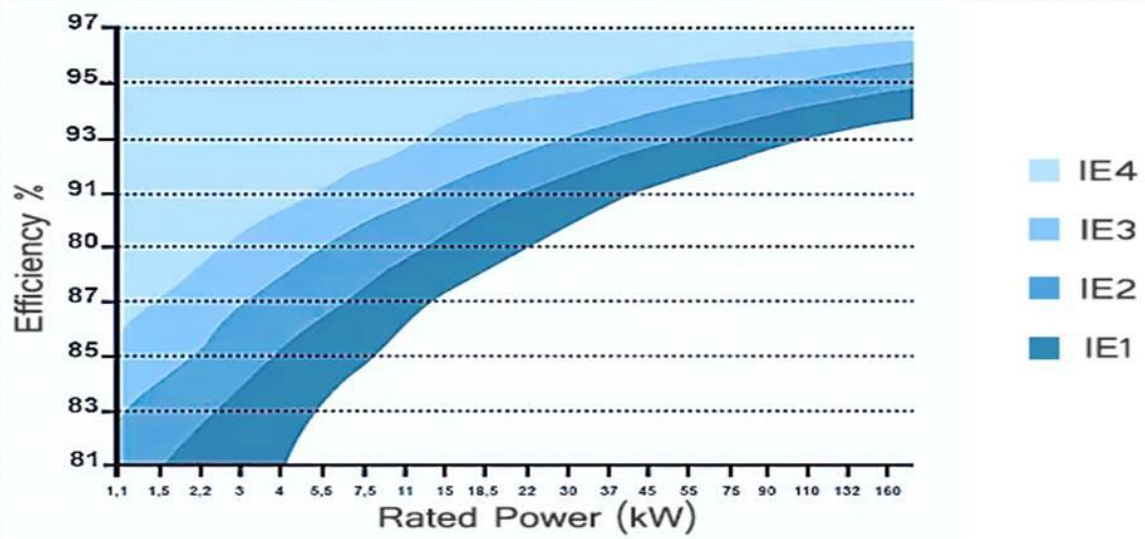
	1	2	3	4	5	6
1 TO 15 HP	76	40	26	15	9	6
16 TO 40 HP	60	30	22	13	8	5
41 TO 150 HP	45	22	20	12	7	4
Load %	0	10	20	30	40	50

Case study of star- delta convertor

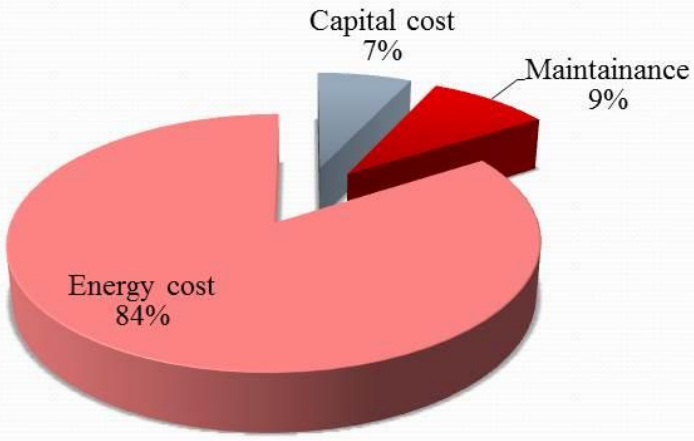


Average saving was estimated to be about 22% with a simple payback period of 9 months

Use of high efficiency motors (IE2, IE3)



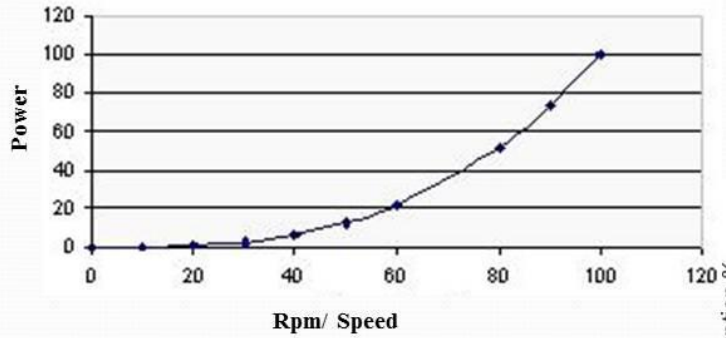
Share of capital cost and running cost

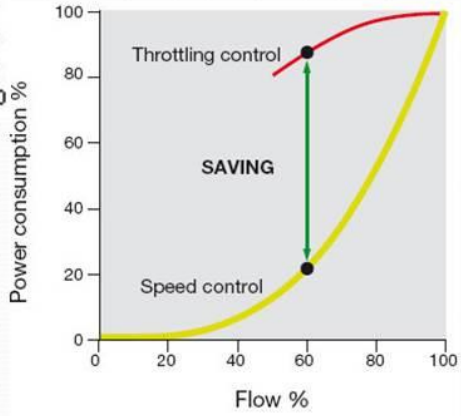


Case Study: Replacement of rewinded standard motors with energy efficient motors

- 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

Speed control of induction motor

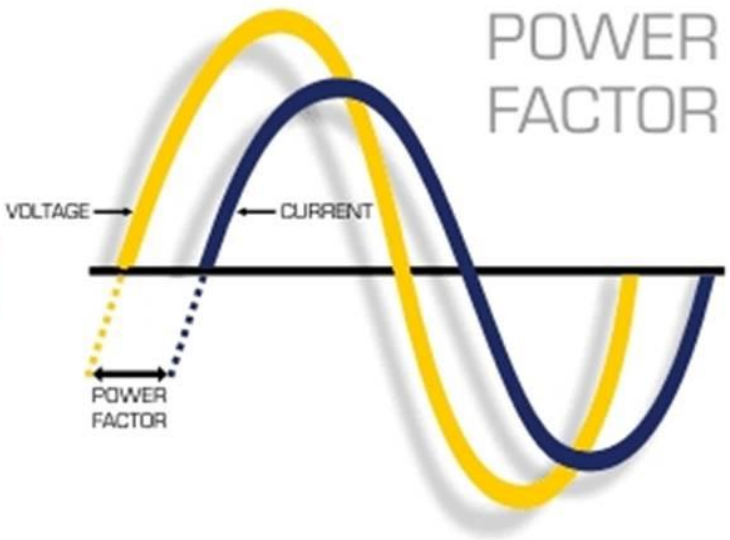




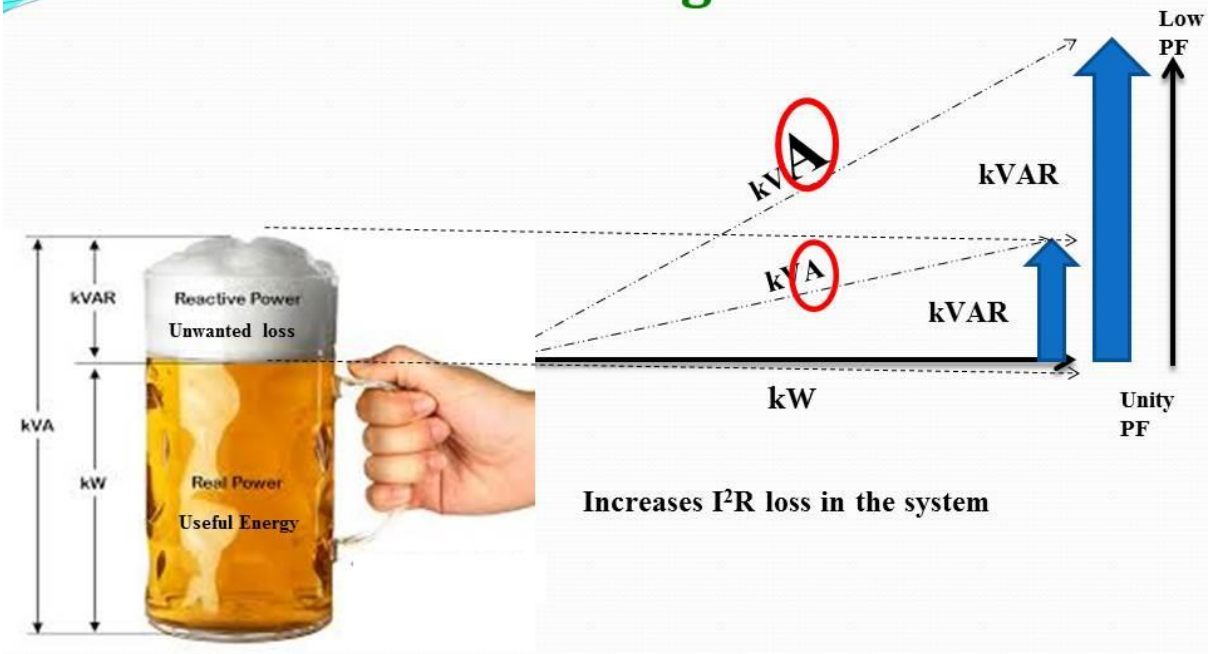
- ✓ **For variable loading , like in case of pump with a variable load can reduce it flow by lowering its RPM and generate substantial saving**

Type of Electrical Systems In Industry

- ✓ Reactive Power

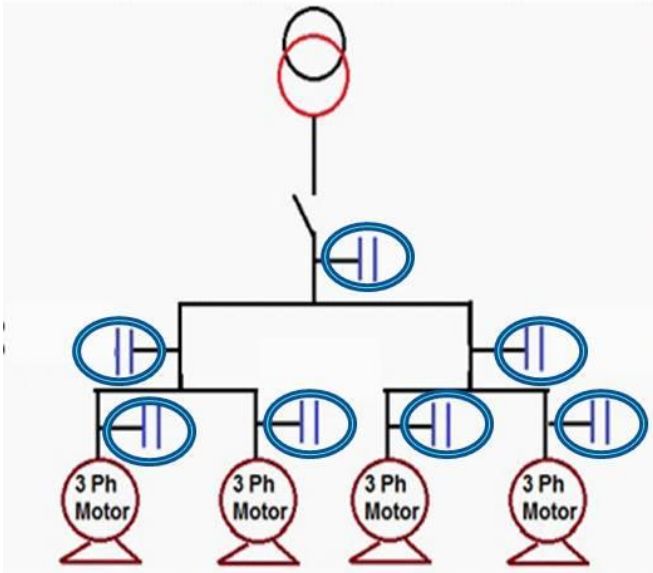


Reactive Power Management



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

Improve power quality

Motor performance affected by

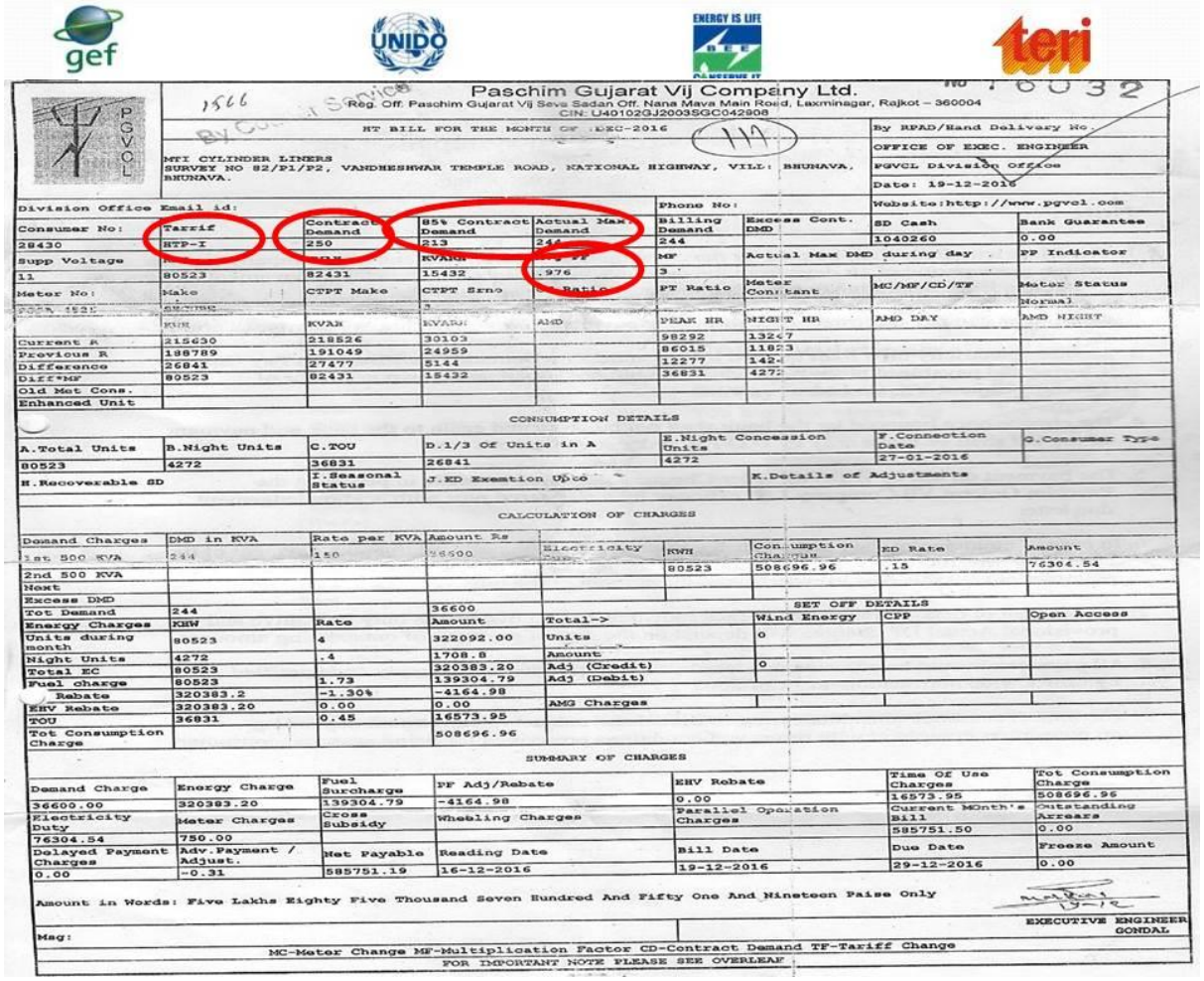
- Poor power quality: too high fluctuations in voltage and frequency
- Voltage unbalance: unequal voltages to three phases of motor

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

Energy Bill Analysis



Paschim Gujarat Vij Company Ltd.
Reg. Off. Paschim Gujarat Vij Seva Sadan Off. Nana Mava Main Road, Laxminagar, Rajkot – 360004
CIN: U40102GJ2003SGC042908

HT BILL FOR THE MONTH OF DEC-2016

By RPAD/Hand Delivery No :
OFFICE OF EXEC. ENGINEER
PGVCL Division Office
Date: 19-12-2016

MTI CYLINDER LINERS
SURVEY NO 82/P1/P2, VANDHESHWAR TEMPLE ROAD, NATIONAL HIGHWAY, VILL: BHUNAVA, BHUNAVA.

Division Office Email id: | Phone No: | Website:http://www.pgvcl.com

Consumer No:	Tarrif	Contract Demand	85% Contract Demand	Actual Max Demand	Billing Demand	Excess Cont. DMD	SD Cash	Bank Guarantee
28430	HTP-I	250	213	244	244		1040260	0.00
Supp Voltage			KVAH		MF	Actual Max DMD during day		PF Indicator
11	80523	82431	15432	.976	3			
Meter No:	Make	CTPT Make	CTPT Srno	PT Ratio	PT Ratio	Meter Constant	MC/MF/CD/TF	Meter Status
								Normal
	KWH	KVAH	KVARH	AMD	PEAK HR	NIGHT HR	AMD DAY	AMD NIGHT
Current R	215630	219826	30103		98292	132[illegible]7		
Previous R	188789	191049	24959		86015	11823		
Difference	26841	27477	5144		12277	142[illegible]		
Diff*MF	80523	82431	15432		36831	427[illegible]		
Old Met Cons.								
Enhanced Unit								

CONSUMPTION DETAILS

A.Total Units	B.Night Units	C.TOU	D.1/3 Of Units in A	E.Night Concession Units	F.Connection Date	G.Consumer Type
80523	4272	36831	26841	4272	27-01-2016	
H.Recoverable SD		I.Seasonal Status	J.ED Exemtion Upto	K.Details of Adjustments		

CALCULATION OF CHARGES

Demand Charges	DMD in KVA	Rate per KVA	Amount Rs
1st 500 KVA	244	150	36600
2nd 500 KVA			
Next			
Excess DMD			
Tot Demand	244		36600
Energy Charges	KWH	Rate	Amount
Units during month	80523	4	322092.00
Night Units	4272	.4	1708.8
Total EC	80523		320383.20
Fuel charge	80523	1.73	139304.79
Rebate	320383.2	-1.30%	-4164.98
EHV Rebate	320383.20	0.00	0.00
TOU	36831	0.45	16573.95
Tot Consumption Charge			508696.96

Electricity	KWH	Consumption Charges	ED Rate	Amount
	80523	508696.96	.15	76304.54

SET OFF DETAILS

Total->	Wind Energy	CPP	Open Access
Units	0		
Amount			
Adj (Credit)	0		
Adj (Debit)			
AMG Charges			

SUMMARY OF CHARGES

Demand Charge	Energy Charge	Fuel Surcharge	PF Adj/Rebate	EHV Rebate	Time Of Use Charges	Tot Consumption Charge
36600.00	320383.20	139304.79	-4164.98	0.00	16573.95	508696.96
Electricity Duty	Meter Charges	Cross Subsidy	Wheeling Charges	Parallel Operation Charges	Current MOnth's Bill	Outstanding Arrears
76304.54	750.00				585751.50	0.00
Delayed Payment Charges	Adv.Payment / Adjust.	Net Payable	Reading Date	Bill Date	Due Date	Freeze Amount
0.00	-0.31	585751.19	16-12-2016	19-12-2016	29-12-2016	0.00

Amount in Words: Five Lakhs Eighty Five Thousand Seven Hundred And Fifty One And Nineteen Paise Only

EXECUTIVE ENGINEER
GONDAL

Mag:

MC-Meter Change MF-Multiplication Factor CD-Contract Demand TF-Tariff Change
FOR IMPORTANT NOTE PLEASE SEE OVERLEAF

Tariff of PGVCL HTP-1

13. RATE: HTP-I

This tariff will be applicable for supply of electricity to HT consumers contracted for 100 kVA and above for regular power supply and requiring the power supply for the purposes not specified in any other HT Categories.

13.1 DEMAND CHARGES:

13.1.1 For billing demand up to contract demand

(a)	For first 500 kVA of billing demand	Rs. 150/- per kVA per month
(b)	For next 500 kVA of billing demand	Rs. 260/- per kVA per month
(c)	For billing demand in excess of 1000 kVA	Rs. 475/- per kVA per month

13.1.2 For Billing Demand in Excess of Contract Demand

For billing demand in excess over the contract demand	Rs. 555 per kVA per month

PLUS

13.2 ENERGY CHARGES

For entire consumption during the month		
(a)	Up to 500 kVA of billing demand	400 Paise per Unit
(b)	For billing demand above 500 kVA and up to 2500 kVA	420 Paise per Unit
(c)	For billing demand above 2500 kVA	430 Paise per Unit

13.3 TIME OF USE CHARGES:

	For energy consumption during the two peak periods, viz., 0700 Hrs. to 1100 Hrs. and 1800 Hrs. to 2200 Hrs.	
(a)	For Billing Demand up to 500 kVA	45 Paise per Unit
(b)	For Billing Demand above 500 kVA	85 Paise per Unit

13.4 BILLING DEMAND:

The billing demand shall be the highest of the following:

(a) Actual maximum demand established during the month

(b) Eighty-five percent of the contract demand

(c) One hundred kVA

13.6 POWER FACTOR ADJUSTMENT CHARGES:

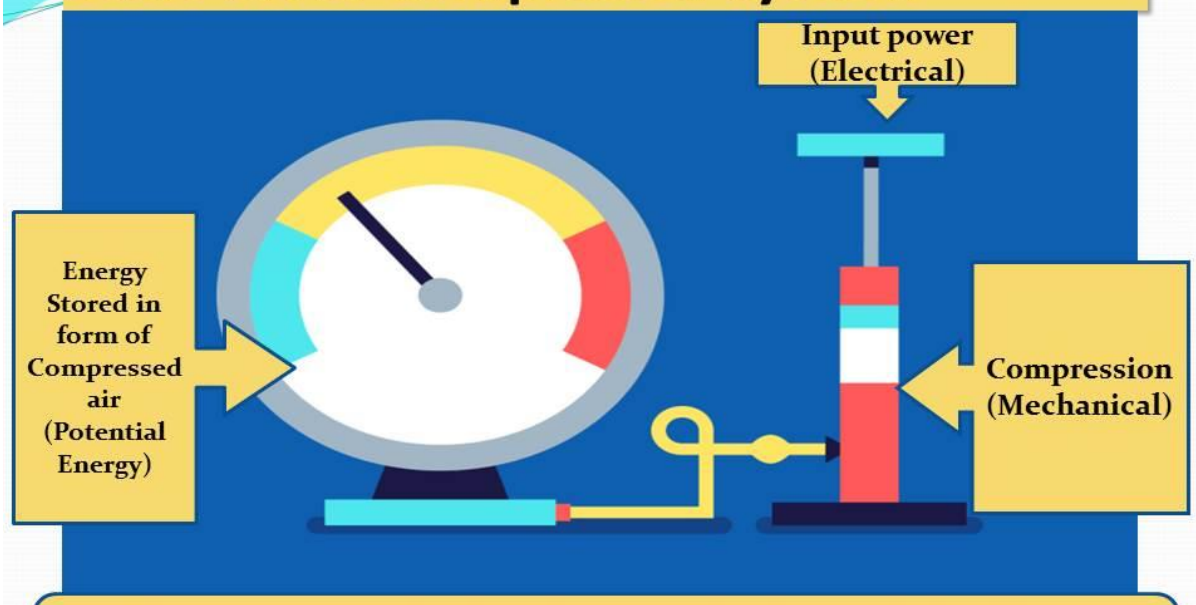
13.6.1 Penalty for poor Power Factor:

(a) The power factor adjustment charges shall be levied at the rate of 1% on the total amount of electricity bills for the month under the head "Energy Charges", arrived at using tariff as per para 13.2 of this schedule, for every 1% drop or part thereof in the average power factor during the month below 90% up to 85%.

(b) In addition to the above clause, for every 1% drop or part thereof in average power factor during the month below 85% at the rate of 2% on the total amount of electricity bill for that month under the head "Energy Charges", arrived at using tariff as per para 13.2 of this schedule, will be charged.

COMPRESSED AIR SYSTEM

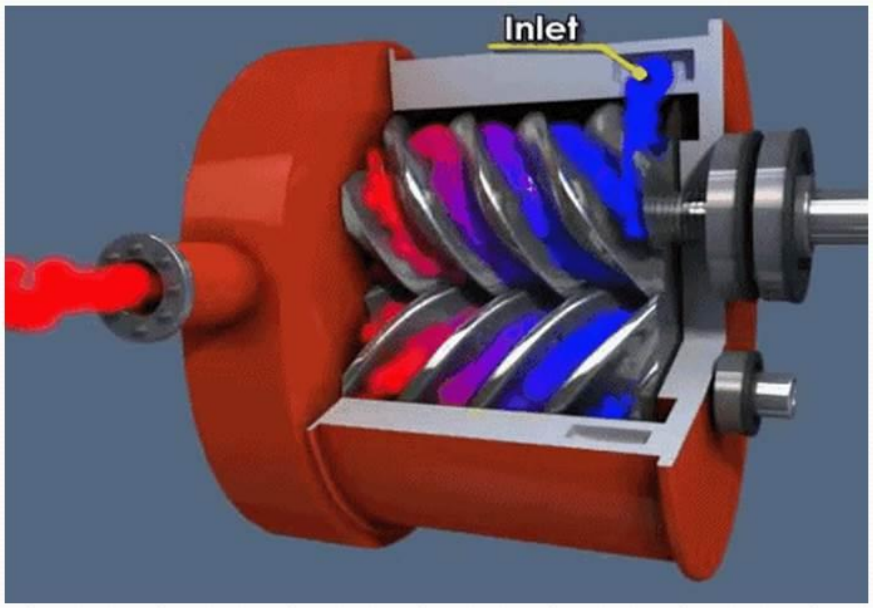
Basic of Air compressor system



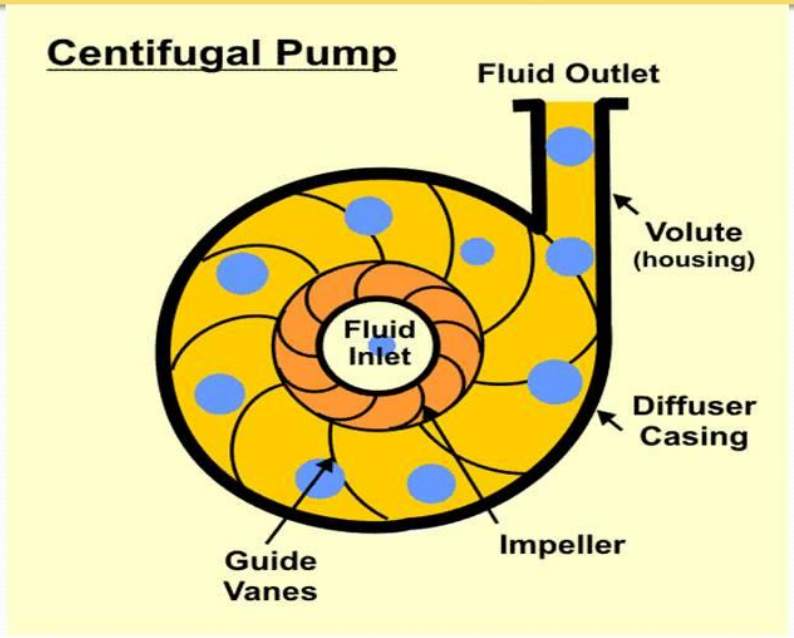
Air compressor is an equipment that converts electricity into potential energy stored as pressurized air

Reciprocating

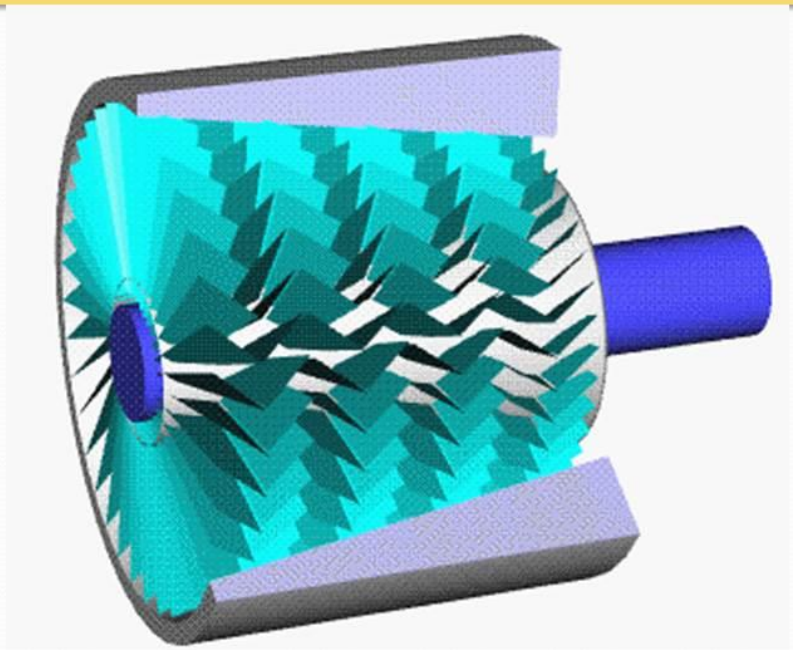
Rotary



Centrifugal



Axial

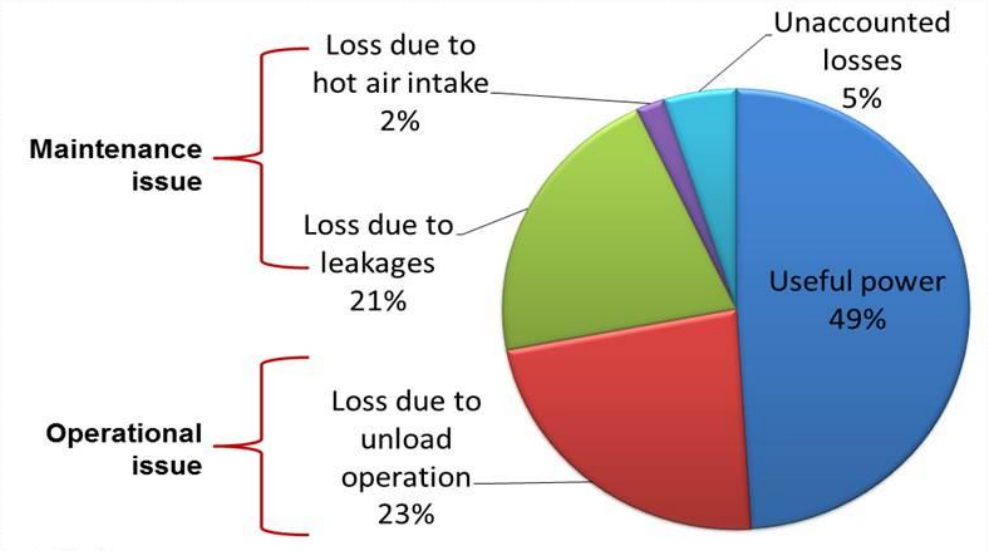


Energy utilized in compressed air

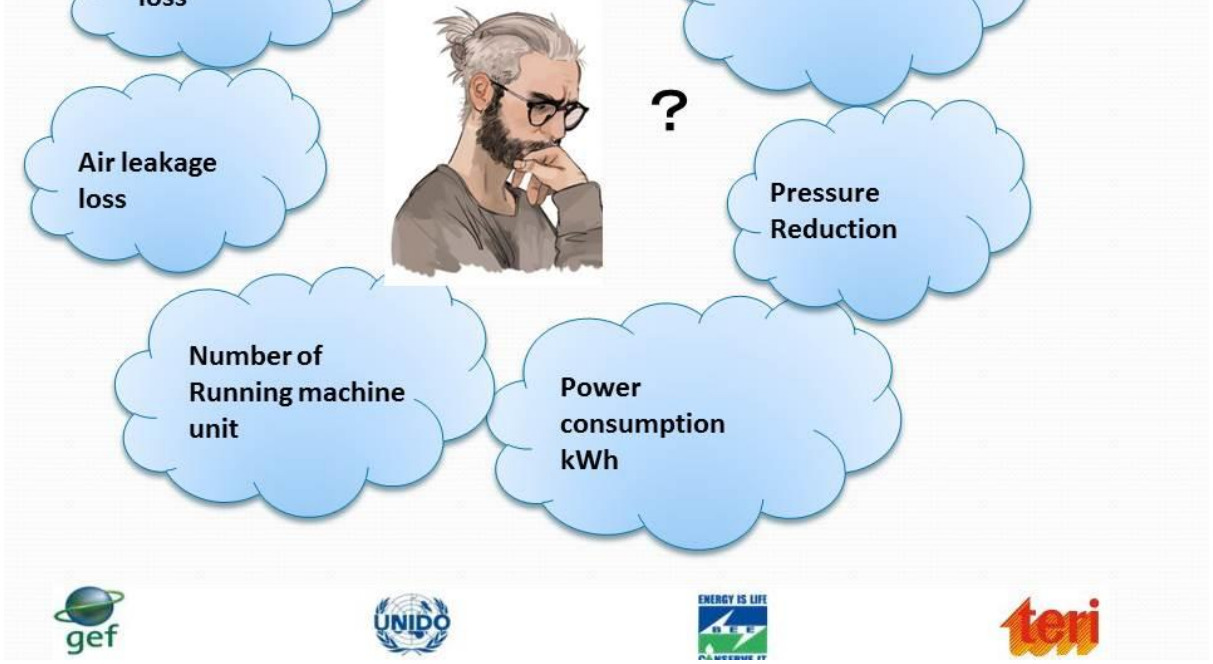
Energy stored in compressed air
30%

Heat Loss due to compression
70%

What you do with the stored energy



What can you save ?



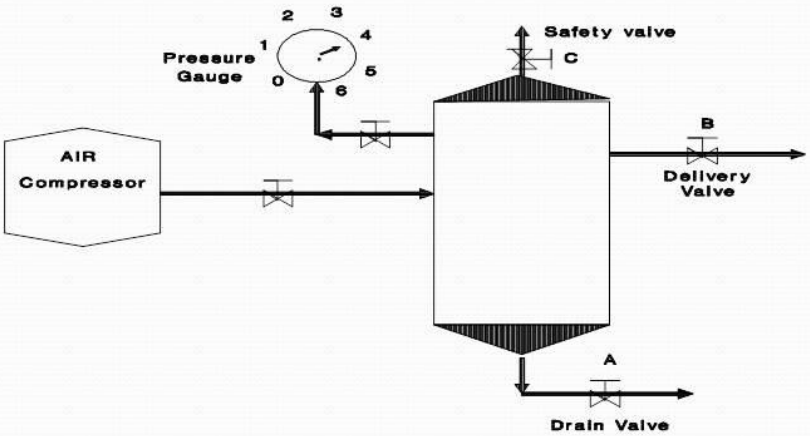
How can you save ?

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

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



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)

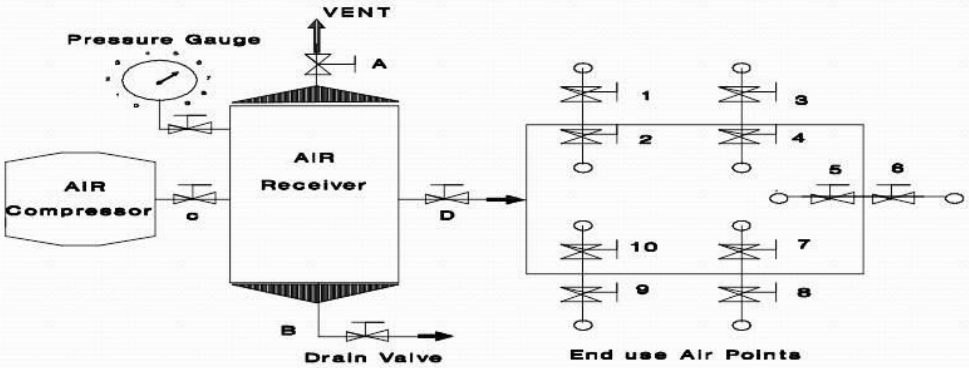
V = Storage volume including receiver, after cooler and delivery piping (m^3)

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

- Specific Power Consumption (SPC) i.e. kW/volume flow rate
- e.g. kW/cfm or kW/m^3/min

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



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


Thank you
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ENERGY IS LIFE
teri

Capacity Building of Local Service Providers (LSPs)

Electric motors

Good practices in Operation, Maintenance and Rewinding

Supported by

GEF-UNIDO-BEE Project
Promoting Energy Efficiency and Renewable Energy in selected MSME clusters in India

Course of training

1	Motor selection
2	Motor maintenance & rewinding
3	Good practices in rewinding
4	Best operating practices
5	Basic instruments and tools
6	References

Motor selection

- Cost of operation – Life cycle costs
- Proper sizing of motors
- Starting system/controllers
- Nature of load

Motor driven systems account for about 55% of global industrial electricity consumption

Source: IEA report on energy efficiency policy opportunities for electric motor driven system

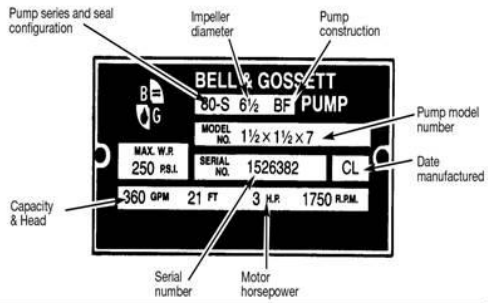
Cost of operation – Life cycle costs

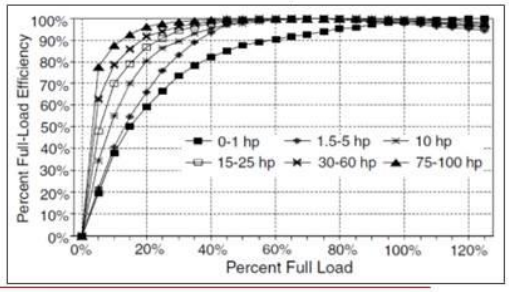
Description	Unit	IE1	IE2	IE3
Motor Load Requirement	kW	13.5	13.5	13.5
Motor Rating	kW	15	15	15
Motor Efficiency at operating load	%	88.7	90.6	91.4
Input Power	kW	15.2	14.9	14.8
Motor loading	%	90.0	90.0	90.0
Annual electricity consumption (@ 5000 hours per year)	kWh/Year	76,099	74,503	73,851
Difference 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.

Proper sizing of motor

- Motors are often oversized because of:
  - Uncertainty about load
  - Allowance for load growth
  - Rounding up to the next size
  - Availability
- Rating of motor determines based on capacity of associated load
  - For example, pump required 3 hp motor, if high rating motor used, power consumption will be more.
- Motor loading should be in the range of 75 - 95% of rated capacity.





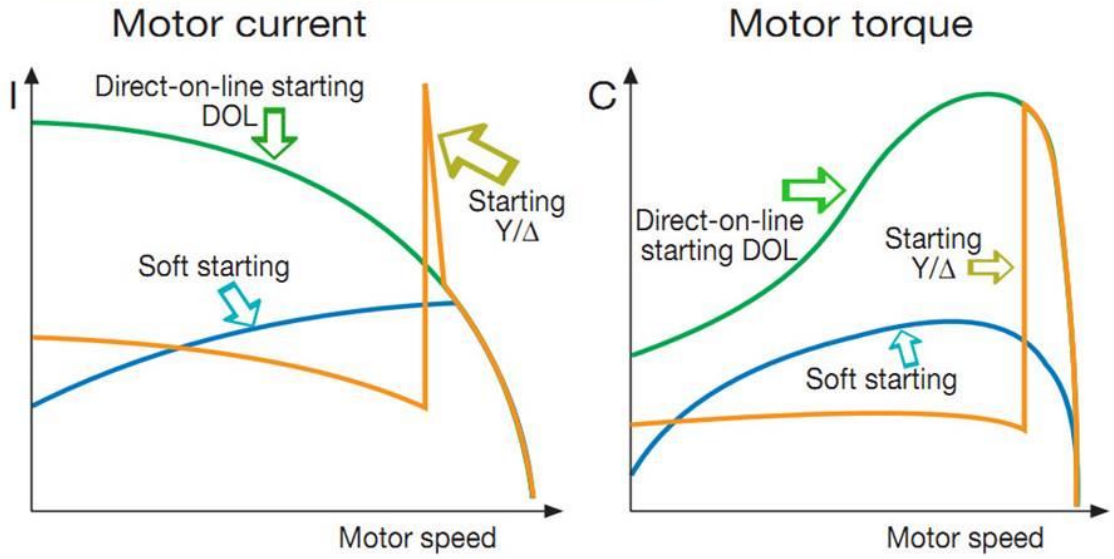
Proper sizing of motor...

Description	Unit	Motor rating		
Motor Load Requirement	kW	15	15	15
Motor Rating	kW	15	30	55
Motor Efficiency at operating load	%	89	89	84
Input Power	kW	16.9	16.9	17.9
Motor loading	%	100.0	50.0	27.3
Annual electricity consumption (@ 5000 hrs /Yr)	kWh/Year	84,270	84,270	89,286
Difference in electricity consumption	kWh/Year	-	-	5,016
Increased in running (@ Rs. 6.5 per kWh)	Rs./Year	-	-	32,604
Initial investment	Rs.	35,250	70,500	1,29,250
Increase in Investment	Rs.	-	35,250	94,000
Total operational cost for first year	Rs.	5,83,003	6,18,253	7,09,607
%age incremental life cycle cost	%	-	6.0	20.5

Apart from high initial and running cost, oversized Motors lead to:

- Higher maximum demand due to poor power factor.
- Higher cable losses, switchgear cost therefore higher installation cost.
- Higher rewinding cost (in case of motor burnout).

Starting system/controllers



Starting system/controllers...

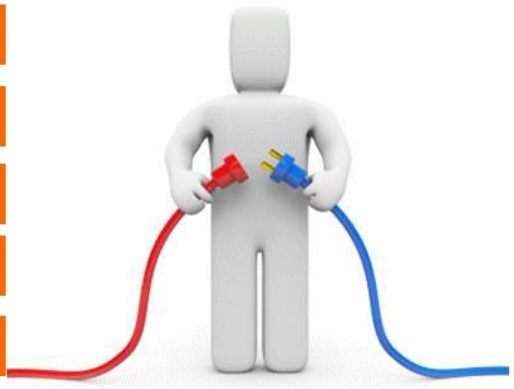
DOL Starter	Y-Δ Starter	Soft Starter
Used up to 5 hp	Used 5 hp to 20 hp	Used above 20 hp
Does not decrease the starting current	Decrease the starting current up to 1/3 times	Decrease the starting current as required
Low cost option	Moderate cost	High cost option
It connect motor directly with supply for starting and running	It connect motor initially in **Y** for starting and convert in **Δ** for running	It connect motor directly with supply for starting and running

Nature of load

- Rated at the speed the shaft will turn in revolutions per minute (rpm) when motor is operating at full speed
- Rpm of motor should be speed needed to operate equipment at proper speed
- Duty cycle – If the application load is variable in nature or idle time slots, duty cycle become a critical factor in selection of motor

Course of training

1. Motor selection
2. Motor maintenance & rewinding
3. Good practices in rewinding
4. Best operating practices
5. Basic instruments and tools
6. References



Proper Lubrication

- Improper lubrication practice can cause bearing failure.
- Too much lubrication results in churning and higher heat loss.
- In-sufficient lubrication can increase the component failure due to excessive friction and heat.
- Oil and grease on the stationary switch contacts may cause them to overheat, arc or burn, and even to weld themselves closed.
- Lubricants harm many internal motor parts.
- Use the recommended grade of lubricant, especially in severe duty applications.

Belts and Pulleys

- The efficiency of mechanical power transmission depends on grip between pulley and belt (Co-efficient of friction - μ & strength (Tensile))
- μ (Co-efficient of friction)
  - Rubber coated canvas belts – 0.2 or leather belts available earlier
  - V-Belt, effective μ improved up to 0.55.
  - Chrome leather belts, μ improved to 0.7

S. No	Motor HP	Losses %
1	2	8-15
2	3	7-13
3	4	6-12
4	6	5.5-10
5	8	5-9
6	10	4.5-8.2
7	20	3.5-7
8	30	3.2-6
9	40	3-5.5
10	60	2.8-5
11	80	2.5-4.5
12	100	2.5-4.5

Course of training

1	Motor selection
2	Motor maintenance & rewinding
3	Good practices in rewinding
4	Best operating practices
5	Basic instruments and tools
6	References

Preparation of work table

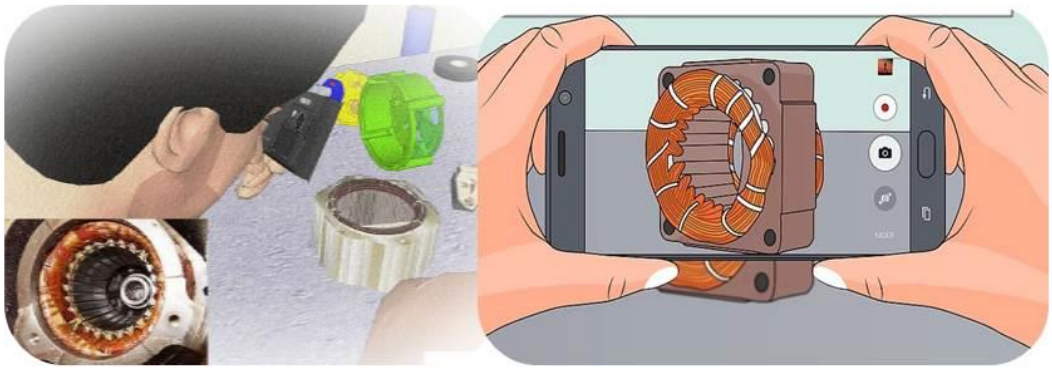
❑ Clean your work surface to make sure it's free of dirt and dust

Dismantling to reveal armature and winding

- Remove the motor housing to reveal the armature, stator, and the windings
- Deployment of excessive force should be avoided while dismantling the motor housing as these may damage the insulation

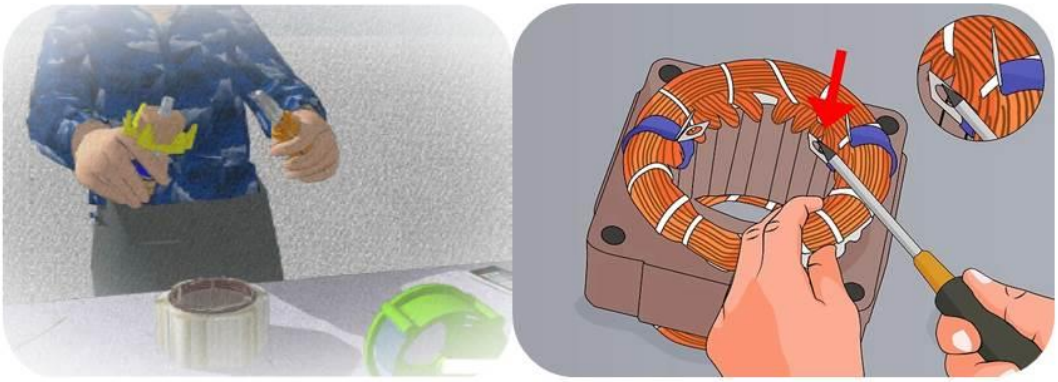
Documentation – Existing condition

- Document the present configuration by taking notes or photographs.
  - Important parameters such as rated current, capacity, type of winding to prevent deviation from design parameters post rewinding.



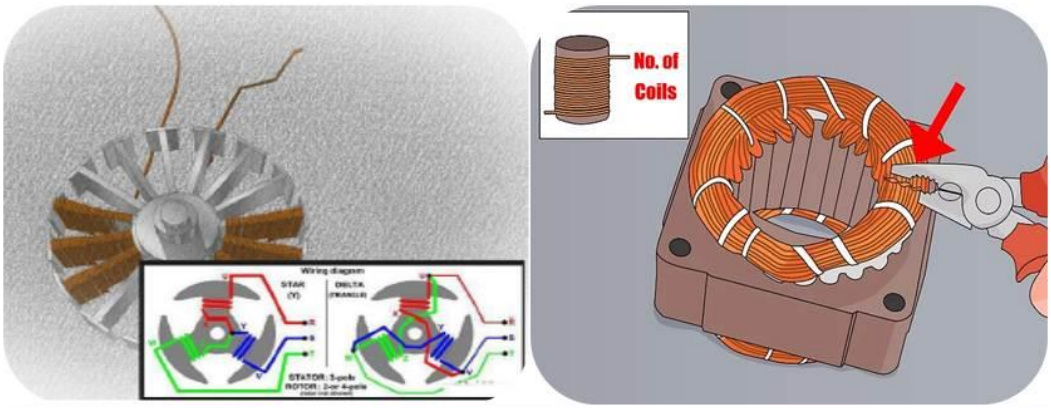
Removing wire from brush tabs

- Care should be taken to bend the tabs gently (and as little as possible) to prevent any damage.
- Also, the wires should be completely removed from the tabs before cutting the coils of the wind.



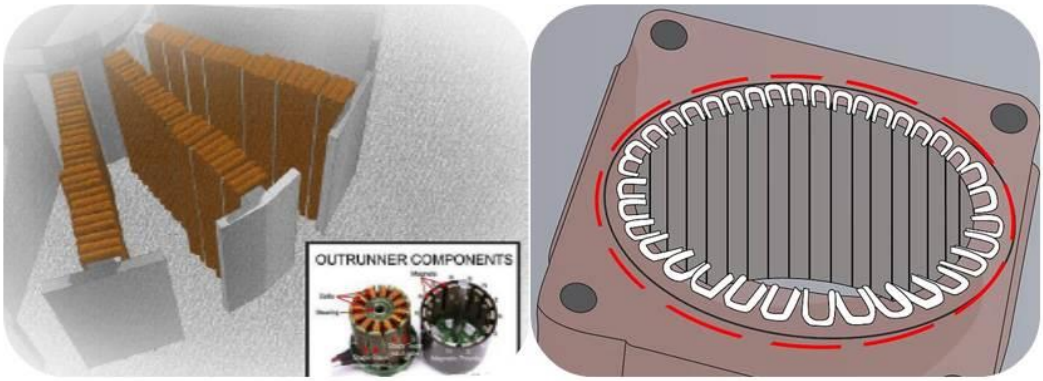
Cutting the coils

- The easiest place to cut is at the top of the coils (top of armature and/or stator posts).
- The number of winds in each coil should be exactly counted to ensure replication.



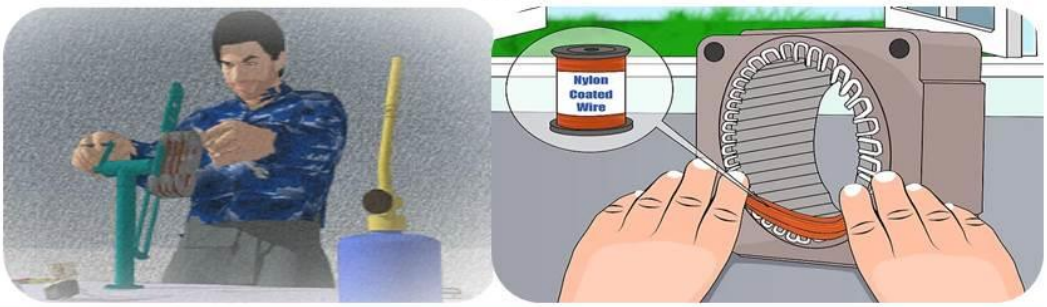
Check for insulation damage

- If the insulation lining the steel laminate areas is in good condition it should be put back.
- In case if it's damaged or burned it should be replaced with similar material as specified by the supplier.



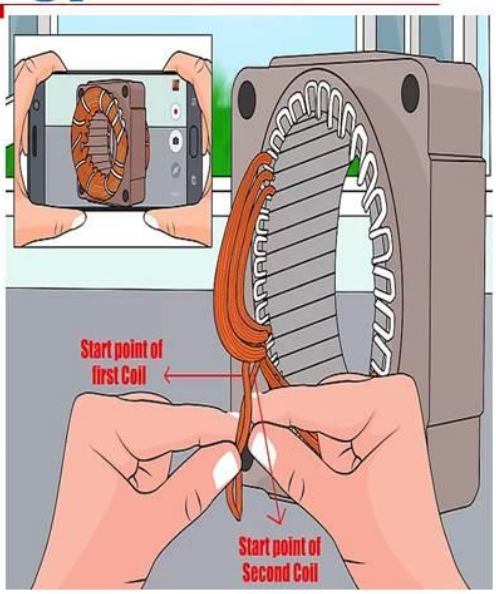
Rewound the Motor

- Rewind the armature and/or stator using the same gauge and type of magnet wire that was on the original motor.
- If you're more experienced, you may wish to upgrade your wire's quality, substituting a nylon-and-polyurethane-coated wire for the original enamel-coated wire, for instance.
- In case if it's damaged or burned it should be replaced with similar material as specified by the supplier.



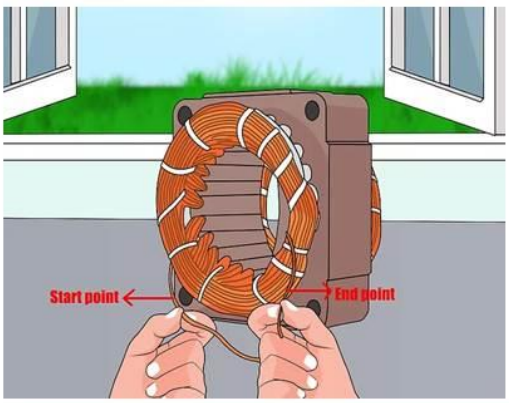
Recreate the exact winding pattern

- When beginning first winding, leave the end of first winding free but long enough to reach the first tab. The last winding will attach to the same point.
- Crimp all the other windings down as you work to hold the wire in place. You do the winding with one long wire, so don't cut anything as you go.
- Before you crimp the wire down behind the tabs, use a sharp knife or sandpaper to remove the insulation from the wire at the point where it makes contact with the tab. Make sure you only remove as much insulation as is necessary to create good contact.

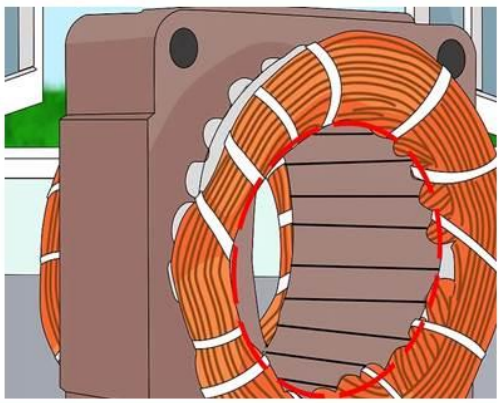


Check the following

Connect the end of the last winding and the loose wire you left in the first winding to the tab where you began



Check to make sure that none of the wires connecting to the tabs are touching.



Re-assemble the motor housing

- Post re-assembly the motor should be run for one to two hours in the rewinding facility to ensure safe operation before being dispatched.

Few Points to Remember

- Don't go for rewinding again and again for the same motor : Efficiency typically decreases for every rewinding unless special care is taken during rewinding practice
- Get the rewinding done through skilled persons having proper repair shop.
- Make sure the work table is clean and free from dust, dirt, oil and any unwanted particles.
- While dismantling the winding from slots, care should be taken to prevent use of excessive of force as this may damage the core.
- It is better to apply heat for easy removal of windings. This heating should be controlled and it should be ensued that the core is not exposed to excessive temperatures beyond specified by OEM.

Few Points to Remember...

- ❑ Important parameters such as power, current, type of winding design, number of turns, wire gauge etc. should be documented carefully to ensure replication of past performance parameters.
- ❑ Use wire of same gauge and material. Don't use aluminum wire in place of copper wire.
- ❑ While removing wire from the brush tabs, care should be taken to bend the tabs gently and as little as possible to prevent any damage. Wires should be completely removed from the tabs before cutting the coils.
- ❑ Damaged insulation should be replaced with the same type and insulation rating as specified by the OEM.
- ❑ The user should insist for efficiency test post rewinding.

Course of training

1	Motor selection
2	Motor maintenance & rewinding
3	Good practices in rewinding
4	Best operating practices
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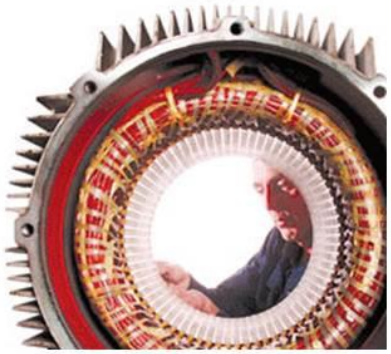
6	References

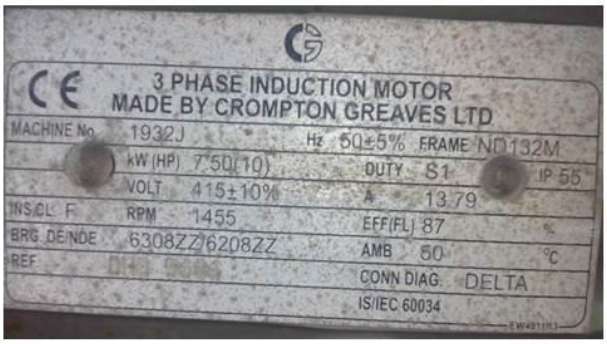


Best operating practices

- Know your motor name plate
- Observe condition of electrical contacts
- Maintain good condition of MCC panels
- Maintain service history card
- Keep, maintain and practice maintenance schedule
- Adopt predictive maintenance techniques

Know your motor name plate

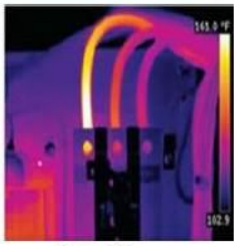
- ❑ Ensure that there is a name plate on motor
- ❑ Nameplate should be clean and clearly readable
- ❑ Important Information to Note
  - Rated Volts & Full Load Amps
  - Rated Full Load Speed
  - Class of Insulation
  - Rated HP
  - Efficiency at Full Load
  - Power Factor at Full Load



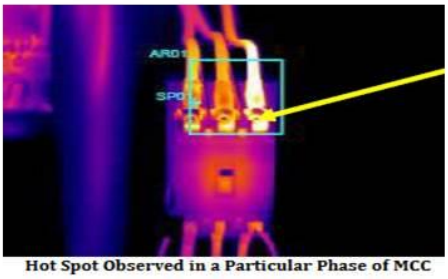
Observe condition of electrical contacts

- Loose/ corrosive contacts should be identified and attended to prevent any mishap/failure.
- Visual inspection may not reveal the problem at all.
- Temperature monitoring by using non contact type infrared cameras should be conducted to ascertain the quality of electrical connections, at least once in a year.
- More number of inspections will enhance the reliability.

Visual Image
No Problem Detected



Thermal Image
High Temperature in a Phase



Hot Spot Observed in a Particular Phase of MCC

Maintain good condition of MCC panels

- Indicators on the MCC panel should always be in operating condition.
- Connections should be made with proper lugs.
- Panel doors should always be kept in closed condition.
- Ensure proper ventilation around MCC panel.

Connections without lugs

Unsafe method of connections from joints without using proper lugs

Outer insulation damaged in live electrical wires

Properly Maintained MCC Panel – Ideal Case

Maintain service history card

- ❑ Type of problem/failure (whether mechanical or electrical)
- ❑ Whether problem solved internally
- ❑ Major action takes
  - Preventive Maintenance,
  - Replacement of Motor or motor parts
  - Rewound

Sample History Card of Motor Stoppage

Motor Id : **Location:** **Motor Rating:**

Date	Observation	Type of Failure	Action Taken	Stoppage Time	Comments/ Additional Points
dd/mm/yyyy	Bearing Seizure	Mechanical	Bearing Replaced	4 hours	

Keep, maintain and practice maintenance

Activity	What to Measure/ Observe	How to Measure / Perform	By Whom	Frequency of Measurement
Visual inspection of motor	▪ Abnormal noise ▪ Unusual Smell ▪ General Cleanliness	Human sensor such as touch, ear , nose, eye	Shift operator	Everyday
General cleaning	▪ Dirt & dust ▪ Unwanted material ▪ Improper ventilation	clean cloths, brushes and tiny blowers	Maintenance Team	Everyday
Check lubrication	▪ Grease quantity and colour in the cavity ▪ Oil level indicator ▪ Bearing temperature	▪ Visual observation ▪ Infrared gun	Maintenance Team	Once in a week
Check power supply quality	▪ Phase to phase voltage & current	▪ Panel display/Clamp meter	Maintenance Team	Once in a week/Month

Adopt predictive maintenance techniques

Technique	Instruments	Measurable parameters	Diagnosis	Frequency of Measurement
Vibration Monitoring	▪ Vibro meter	Vibration at bearing houses	Compare with recommended limit	Once is 3 months
Thermography	▪ Thermal imager	Temperature (Thermal image)	Temperature at joint and connections	Once is 12 months
Shock pulse	▪ Shock pulse meter	▪ Amplitude of shock generated at bearing housing	Bad/damaged bearing, inner or outer race damaged	Once is 6 months

Course of training

1. Motor selection
2. Motor maintenance & rewinding
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5. Basic instruments and tools
6. References

Basic instruments and tools

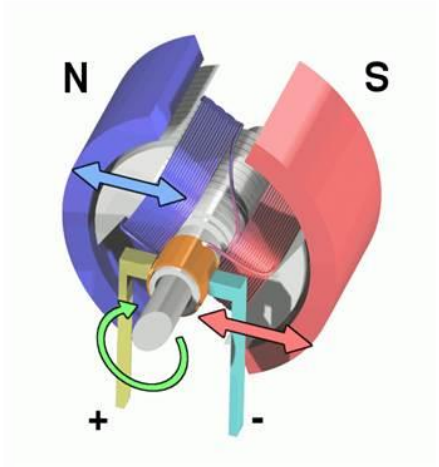
- Power analyser
  - Voltage, Current , PF and Active Power (kW)
  - Energy loss calculations
  - Unbalance check – Voltage and Current
- Thermal Imager
  - Surface temperature
  - Leakage current /hot spots identification
  - Motor and other equipment performance analysis.

Basic instruments and tools

- Multimeter
  - electric current, voltage, and usually resistance,
  - typically over several ranges of value
- Stroboscope/tachometer
  - revolutions per minute (RPM)

Course of training

1	Introduction
2	Type of electric motors
3	Assessment of electric motors
4	Energy efficiency opportunities
5	Success stories
6	References



References

- **Energy-Efficiency Policy Opportunities for Electric Motor-Driven Systems (IEA, 2011)**
  https://www.iea.org/publications/freepublications/publication/EE_for_ElectricSystems.pdf
- **Bureau of Energy Efficiency (Government of India), India**
  www.beeindia.gov.in
- **The Energy and Resources Institute (TERI), India**
  www.teriin.org
- **International Copper Association of India, India**
  www.copperindia.org
- **All India Electric Motor Manufacturers Association (AIEMMA)**
- **US Department of Energy**
  www.energy.gov
- **New Developments in IEC Standards for Motors Driven by Frequency Converters**
  http://motorsummit.ch/data/files/MS2014/mittwoch/620ms14doppelbauer.pdf
- **Motor Challenge Programme (European Commission, 2003)**
  http://iet.jrc.ec.europa.eu/energyefficiency/motorchallenge