Regn No: _________________

Name: ___________________

(To be written by the candidates)

8^{th} NATIONAL CERTIFICATION EXAMINATION – May, 2009 FOR ENERGY MANAGERS & ENERGY AUDITORS

PAPER – 3:	**Energy Efficiency in Electrical Utilities**		
Date: 24.05.2009	Timings: 0930-1230 HRS	Duration: 3 HRS	Max. Marks: 150

General instructions:

- *Please check that this question paper contains **8** printed pages*
- *Please check that this question paper contains **64** questions*
- *The question paper is divided into three sections*
- *All questions in all three sections are compulsory*

1 *All parts of a question should be answered at one place*

Section – I: OBJECTIVE TYPE Marks: 50 x 1 = 50

(i) Answer all **50** questions
(ii) Each question carries **one** mark
(iii) Please hatch the appropriate oval in the OMR answer sheet with Black Pen or Black HB Pencil, as per instructions

1	Select the wrong statement: a) 'Heat Rate' reflects the efficiency of generation. **<u>b) 'Heat Rate' is the heat input in kilo Calories or kilo Joules, for generating 'one' kilo Watt of electrical output.</u>** c) 'Heat Rate' is inverse of the efficiency of power generation. d) design 'Heat Rate' of a 500MW thermal generating unit is lower than that of a 110 MW thermal generating unit.
2	In an industry, if the drawl over a recording cycle of 30 minutes is : 2500 kVA for 10 minutes 3600 kVA for 6 minutes 4100 kVA for 12 minutes 3800 kVA for 2 minutes The MD recorder will be computing MD as **<u>a) 3446</u>** b) 3600 c) 3800 d) 4100
3	A bulk power factor correction system which is left connected to an installation where the load has reduced considerably may result in

	<u>**a) leading power factor at input electric supply**</u> b) damage to the installation cables c) considerable reduction in maximum demand d) a reduced supply tariff
4	The total loss for a transformer loading at 60% and with no load and full load losses of 3 kW and 25 kW respectively, is a) 3 kW b) <u>**12 kW**</u> c) 18 kW d) 25 kW
5	A pure resistive load in an alternating current (AC) circuit draws only a) lagging reactive power b) <u>**active power**</u> c) leading reactive power d) active apparent power
6	The nearest kVAr compensation required for improving the power factor of a 1000 kW load from 0.95 leading power factor to unity power factor is a) 328 kVAr b) 750 kVAr c) 1000 kVAr d) <u>none of the above</u>
7	The ratings of the PF correction capacitors at motor terminals for a 37 kW induction motor at 3000 rpm synchronous speed will be---------------------in comparison to the same sized induction motor at 1500 rpm synchronous speed a) more b) <u>**less**</u> c) same d) dependant on the connected load
8	The largest potential for electricity savings with variable speed drives is generally in <u>**a) variable torque applications**</u> b) constant torque applications c) conveyor belt applications d) balance torque applications
9	A 7.5 kW, 415 V, 15 A, 970 RPM, 3 phase rated induction motor with full load efficiency of 86% draws 7.5 A and 3.23 kW of input power. The percentage loading of the motor is about a) <u>37 %</u> b) 43 % c) 50% d) none of the above
10	Select the correct statement? a) efficiency of an induction motor remains same at all the loading <u>b) squirrel cage induction motors are comparatively more efficient than Slip ring induction motors of the same ratings.</u> c) power factor of an induction motor remains constant during 50 -100% loading conditions d) slip of the induction motor is more at the full load than at the part load
11	A two pole induction motor operating at 50 Hz, with 1% slip will run at an actual speed of a) 3000 RPM b) 3030 RPM c) <u>**2970 RPM**</u> d) none of the above
12	A super thermal power station of 2500 MW installed capacity generated 14,000 million units in a year. Its annual Plant Load Factor (PLF) is: a) 60% b) 79% <u>**c) 64%**</u> d) none of the above

13	Select the incorrect statement a) low speed Squirrel cage induction motors are normally less efficient than high speed Squirrel cage induction motors b) t**<u>he capacitor requirement for PF improvement at induction motor terminals decreases with decrease in rated speed of the induction motors of the same sizes</u>** c) induction motor efficiency increases with increase in its rated capacity d) totally-enclosed, fan cooled (TEFC) motors are more efficient than Screen–protected, drip-proof (SPDP) induction motors
14	The efficiency of compressed air system is around **<u>a) 10%</u>** b) 50% c) 60% d) 90%
15	FAD refers to the compressed air at a) at ISO stated conditions b) <u>Inlet conditions</u> c) at outlet conditions d) at STP
16	Select the incorrect statement: a) compressor efficiency will be reduced by about 2 percent for every 250 mm WC pressure drop across the air inlet filters. b) every 4^0C rise in inlet air temperature results in a higher energy consumption by 1 % to achieve equivalent output c) an increase of 5.5^0C in the inlet air temperature to the second stage results in a 2 % increase in the specific energy consumption. **<u>d) compressed air receiver volume should be 100% of the rated hourly free air output</u>**
17	Which of the following is not a part of the vapour compression refrigeration system a) compressor b) evaporator c) condenser d**) <u>absorber</u>**
18	The refrigerant used in vapour absorption systems is a) steam b) **<u>pure water</u>** c) freon d) lithium bromide
19	The COP of a vapour compression refrigeration system is 3.0. If the power input to compressor is 100 kW , the tonnage of refrigeration system is given by **a) <u>85.3</u>** b) 9.48 c) 300 d) none of the above
20	The refrigeration load in TR when 30 m^3/hr of water is cooled from a 14 ^{o} C to 6.5 ^{o} C is about <u>a) 74.4</u> b) 64.5 c) 261.6 d) none of the above
21	<u>The term Refrigeration means</u> a) addition of cooling b) removal of heat **c) <u>removal and relocation of heat</u>** d) replacement of heat
22	For fans, the relation between power P and speed N is a) $\frac{P_1}{P_2} = \frac{N_1}{N_2}$ b) $\frac{P_1}{P_2} = \frac{N_1^{\ 2}}{N_2^{\ 2}}$ c) $\underline{\frac{P_1}{P_2}} = \underline{\frac{N_1^{\ 3}}{N_2^{\ 3}}}$ d) none of the above
23	Friction loss in a piping system carrying fluid is proportional to

	a) fluid flow b) **<u>(fluid flow)^2</u>** c) $\frac{1}{\text{fluid flow}}$ d) $\frac{1}{(\text{fluid flow})^2}$
24	_____ fans are known as "non-overloading" because change in static pressure do not overload the motor a) radial b) forward- curved <u>c) backward-inclined</u> d) tube- axial
25	Ammonia can be used as a refrigerant in a) vapour compression chiller b) vapour absorption chiller <u>c) both vapour compression and absorption chillers</u> d) none of them
26	The value, by which the pressure in the pump suction exceeds the liquid vapour pressure, is expressed as <u>a) net positive suction head available</u> b) static head c) dynamic head d) suction head
27	When the local static pressure in a fluid reaches a level below the vapor pressure of the liquid at the actual temperature, ____________ may occur in a pump. a) water hammering b) water chilling <u>c) cavitation</u> d) none of the above
28	**I**nstallation of "exclusive" transformer for lighting has following advantage a) "Voltage" fluctuations in lighting circuit can be minimized by isolating from the power feeders. b) This will reduce the voltage related problems, which in turn increases the efficiency of the lighting system. c) With proper control device "over voltage" that might occur during lean load or off-peak can be avoided, in turn excess energy consumption and improved lamp life **d) <u>all the above</u>**
29	Parallel operation of two identical fans in a ducted system a) will double the flow b) will double the fan static pressure c) <u>will not double the flow</u> d) will increase flow by more than two times
30	Normally the guaranteed best approach a cooling tower can achieve is a) 5^{o}C b) 8^{o}C c) 12^{o}C **d) <u>2.8 ^{o}C</u>**
31	Select the wrong statement --- a) for a given heat rejection duty, a higher range will reduce the circulating water flow rate b) when the cycle of concentration is left at one, all water left in the cooling tower after evaporation needs to be removed as blowdown. c) a **<u>better indicators for cooling tower performance is Range</u>** d) a cooling tower size will be greater for 20^{o}C Wet bulb temperature (WBT) than for a 30^{o}C WBT, for the same circulation, range and approach
32	Which of the following ambient conditions will evaporate minimum amount of water in a cooling tower a) 35^{o}C DBT and 30^{o}C WBT b) 38^{o}C DBT and 31^{o}C WBT c) <u>38^{o}C DBT and 37^{o}C WBT</u> d) 35^{o}C DBT and 29^{o}C WBT

33	Input power to the motor driving a pump is 30 kW. The motor efficiency is 0.9. The power transmitted to the water is 16.2 kW. The pump efficiency is <u>a) 60%</u> b) 90% c) 54% d) none of the above
34	A 500 cfm reciprocating compressor is operating to meet a constant demand of 300 cfm. The least cost energy efficient solution will be a) load and unload b) reducing the speed of compressor by increasing the compressor pulley size appropriately c) variable frequency drive d) <u>reducing the speed of compressor by reducing the motor pulley size appropriately</u>
35	Which of the following lamp has the highest efficacy? a) metal halide b) halogen lamps c) HPMV d) <u>HPSV</u>
36	Harmonics are generated by a) <u>variable frequency drive</u> b) fluid coupling c) eddy current drive d) energy efficient motor
37	The inputs required for an automatic power factor controller using kVAR control a) current b) voltage c) capacitance d) <u>both a and b</u>
38	The unit of one lux is a) 1000 lumen per square feet b) 10 lumen per square meter c) <u>1 lumen per square meter</u> d) 1 lumen per square feet
39	The efficiency of a pump does not depend on a) suction head b) discharge head c) density of fluid d) <u>motor efficiency</u>
40	The flow output of which of the following changes with the discharge pressure a) reciprocating compressor b) <u>centrifugal compressor</u> c) screw compressor d) none of the above
41	A fan is operating at 970 RPM developing a flow of 3000 Nm^3/hr. at a static pressure of 650 mmWC. If the speed is reduced to 700 RPM, the static pressure (mmWC) developed will be a) 244.3 <u>b) 388.5</u> c) 469 d) none of the above
42	Luminous efficacy of a lamp is given by a) Lux/Watt **b) lumens/Watt** c) Watt/Lux d) Watt/lumens
43	A fluorescent tube light fitted with an electronic choke will a) operate at 50 Hz <u>b) not need a starter</u> c) operate at 0.5 power factor d) none of the above
44	An engineering industry which was operating with a maximum demand of 500 kVA at 0.9 power factor improved its power factor to 0.99 by installing power factor correction capacitors near the load centres. The percentage reduction in distribution losses within the plant will be <u>a) 17.35%</u> b) 1.21% c) 86.75% d) none of the above

45	Lower load side power factor for a DG Set: a) demands higher excitation currents and results in increased losses b) results in higher kVA loading of generator c) results in lower operating efficiency and higher specific fuel consumption of DG set **d) all the above**
46	The main precaution to be taken care by the waste heat recovery device manufacturer to prevent the problem in a DG set during operation is: a) voltage unbalance on generator b) back pressure on engine c) excessive steam generation d) turbulence in exhaust gases
47	Use of soft starters for induction motors results in a) lower mechanical stress b) lower power factor c) higher maximum demand d) all the above
48	Which of the following refrigeration systems uses vacuum for operation ? a) vapour compression system using R-11 b) vapour compression system using HFC 134A c) vapour absorption system using lithium bromide –water d) none of the above
49	Which of the following electrical equipment has the highest efficiency ? a) synchronous motor b) dc shunt motor c) induction motor d) **transformer**
50	Select the incorrect statement: a) transformers operating near saturation level create harmonics b) devices that draw sinusoidal currents when a sinusoidal voltage is applied create harmonics c) harmonics are multiples of the supply frequency d) harmonics occur as spikes at intervals which are multiples of the supply frequency

…………. End of Section – I …………..

Section – II: SHORT DESCRIPTIVE QUESTIONS　　　　Marks: 8 x 5 = 40

(i) Answer all **Eight** questions
(ii) Each question carries **Five** marks

S-1　A water pump of a process plant is analysed for efficiency and following data is collected:

Flow: 60 m^3/hr, Total head: 30 meters, Power drawn by motor– 7.4 kW, Motor efficiency – 88%

Determine the pump efficiency

Answer

Hydraulic power	Q (m^3/s) x total head (m) x 1000 x 9.81 /1000
	(60/3600) x 30 x 1000 x 9.81/1000
Hydraulic power	4.905kW
Power input to pump	7.4x 0.88
	6.512 kW
Pump efficiency	4.905/6.512
	75.32 %

S-2　A DG set is operating at 700 kW loading with 450°C exhaust gas temperature: The DG set generates 8 kg gas/ kWh generated, and specific heat of gas at 0.25 kCal/ kg °C. A heat recovery boiler is installed after which the exhaust temperature drops by 260°C. How much steam will be generated at 3 kg/ cm^2 with enthalpy of 650.57 kCal/ kg. Assume boiler feed water temperature as 80°C.

Answer

= 700 kWh x 8 kg gas generated/ kWh output x 0.25 kCal/ kg °C x (450°C- 260 °C) =2,66,000 kCal/hr

Steam generation = 2,66,000 kCal/hr / (650.57 kCal/kg. – 80) = 466.2 kg/ hr.

S-3 Discuss in brief any three methods by which energy can be saved in an air conditioning system.

Answer:

a) Cold Insulation

Insulate all cold lines / vessels using economic insulation thickness to minimize heat gains; and choose appropriate (correct) insulation.

b) Building Envelop

Optimise air conditioning volumes by measures such as use of false ceiling and segregation of critical areas for air conditioning by air curtains.

c) Building Heat Loads Minimisation

Minimise the air conditioning loads by measures such as roof cooling, roof painting, efficient lighting, pre-cooling of fresh air by air- to-air heat exchangers, variable volume air system, otpimal thermo-static setting of temperature of air conditioned spaces, sun film applications, etc.

e) Process Heat Loads Minimisation

Minimize process heat loads in terms of TR capacity as well as refrigeration level, i.e., temperature required, by way of:

i) Flow optimization
ii) Heat transfer area increase to accept higher temperature coolant
iii) Avoiding wastages like heat gains, loss of chilled water, idle flows.
iv) Frequent cleaning / de-scaling of all heat exchangers

S-4 An energy audit of a fan was carried out. It was observed that fan was delivering 15,000 Nm^3/hr of air at static pressure rise of 60 mm WC. The power measurement of the 3-phase induction motor coupled with the fan recorded 1.80 kW/ phase on an average. The motor operating efficiency was assessed as 0.88 from the motor performance curves. What would be the fan static efficiency ?.

Answer:

Q = 15,000 Nm^3 / hr.= 4.1667 m^3/sec ,
SP = 60 mmWC,
η_{St} = ?,

Power input to motor = 1.8x3 = 5.4 kW
Power input to fan shaft = 5.4 x 0.88 = 4.752 kW

$$\text{Fan static } \eta = \frac{\text{Volume in m}^3\text{/sec x } \Delta P_{st} \text{ in mmWc}}{102 \text{ x Power I/p to shaft}}$$

$$= \frac{4.167 \times 60}{102 \times 4.752}$$

$= 0.5158$

$= 51.58\%$

S-5 Briefly explain transformer losses and how the total transformer losses at any load level can be computed.

Answer:

Transformer losses consist of two parts: No-load loss and Load loss

1. No-load loss (also called core loss) is the power consumed to sustain the magnetic field in the transformer's steel core. Core loss occurs whenever the transformer is energized; core loss does not vary with load. Core losses are caused by two factors: hysteresis and eddy current losses. Hysteresis loss is that energy lost by reversing the magnetic field in the core as the magnetizing AC rises and falls and reverses direction. Eddy current loss is a result of induced currents circulating in the core.

2. Load loss (also called copper loss) is associated with full-load current flow in the transformer windings. Copper loss is power lost in the primary and secondary windings of a transformer due to the ohmic resistance of the windings. Copper loss varies with the square of the load current. ($P=I^2R$).

For a given transformer, the manufacturer can supply values for no-load loss, $P_{NO\text{-}LOAD}$, and load loss, P_{LOAD}. The total transformer loss, P_{TOTAL}, at any load level can then be calculated from:

$$P_{TOTAL} = P_{NO\text{-}LOAD} + (\%\ \text{Load}/100)^2 \times P_{LOAD}$$

Where transformer loading is known, the actual transformers loss at given load can be computed as:

$$= \text{No load loss} + \left(\frac{\text{kVA Load}}{\text{Rated kVA}}\right)^2 \text{full load loss}$$

S-6 List any five energy conservation opportunities in pumping system.

Answer:

1. Avoid over sizing of pumps
2. Consider impeller trimming and other “easy-to implement” alternatives
3. Consider variable speed drives wherever possible
4. Operate pumps near best efficiency point.
5. Modify pumping system/pumps losses to minimize throttling.
6. Stop running multiple pumps - add an auto-start for an on-line spare or add a booster pump in the problem area.
7. Conduct water balance to minimise water consumption
8. Replace old pumps by energy efficient pumps

S-7 Name any five methods of capacity controls for fans (Note: no explanation is required)

Answer

1. Pulley Change
2. Damper Controls
3. Inlet Guide Vanes
4. Variable Speed Drives
5. Parallel Operation

S-8 The power input to a three phase induction motor is 45 kW. If the induction motor is operating at a slip of 1.5% and with total stator losses of 1.80 kW, find the total mechanical power developed.

Solution:

Stator input: 45kW
Stator losses: 1.80 kW
Stator output: 45-1.80= 43.2kW
OR Rotor Input= 43.2 kW
Slip= 1.5%
Mechanical Power Out put= (1-s)x Rotor Input
= 42.552 kW

-------- End of Section – II ---------

Section – III: LONG DESCRIPTIVE QUESTIONS **Marks: 6 x 10 = 60**

(i) Answer all **Six** questions
(ii) Each question carries **Ten** marks

L-1 a) In a Thermal Power Station, the steam input to a turbine operating on a fully condensing mode is 100 Tonnes/Hr. The heat rejection requirement of the steam turbine condenser is 555 kCals/kg of steam condensed. The temperatures at the inlet to and outlet from the turbine condenser are measured to be 27°C and 35° C respectively. Find out the circulating cooling water flow.

b) An energy audit was conducted to find out the ton of refrigeration (TR) of an Air Handling Unit (AHU). The audit observations are as under.

Parameter	AHU
Evaporator area (m^2)	8.0
Inlet velocity (m/s)	1.81
Inlet air DBT (°C)	21.5
RH (%)	75.0
Enthalpy (kJ/kg)	53.0
Out let air DBT (°C)	17.4
RH (%)	90.0
Enthalpy (kJ/kg)	46.4
Density of air (kg/m^3)	1.14

Find out the TR of AHU.

Answer:

The quantum of heat rejected in the turbine condenser=
Quantum of steam condensed (kg) * heat rejection (kcal/kg)
= 100,000 * 555= 55.5 million kcals /Hr

Heat gained by circulating c. w = Heat rejected in the condenser
Circulating water flow= 100,000 * 555/ (35-27) * specific heat (1)

= **6937.5 m^3/ Hr**

b) AHU refrigeration load =

$$\frac{Air\ \ flow\, rate\,(m^3 h)\ x\, Density\, of\ \ air\,(kg/m^3)\ x\, Difference\ in\, enthalpy}{3024\ \ x\, 4.18}$$

AHU = (8.0 x 1.81 x 3600) x (1.14) (53 – 46.4) / (3024 x 4.18)

= 31.03 TR

L-2 Write short notes on

(i) Effect of supply voltage on capacitors rating

(ii) Pump impeller trimming

(iii) Affinity laws for centrifugal machines

i) Ideally capacitor voltage rating is to match the supply voltage. If the supply voltage is lower, the reactive kVAr produced will be the ratio V_1^2 / V_2^2 where V_1 is the actual supply voltage, V_2 is the rated voltage.

L-3 Fill in the blanks for the following

1. **The intersection point of the pump curve and the system curve is called_____________**
2. **Presenting the load demand of a consumer against time of the day is known as______**
3. **The vector sum of active power and reactive power is ____.**
4. **The ratio of isothermal power to actual measured input power of an air compressor is known as------:**
5. **The input energy for refrigeration in vapour absorption refrigeration plants is____**
6. **The fan which is choosen for moving large flows against relatively low pressures is_____ curved fan.**
7. **The system resistance in a fan ducting system refers to ____________ pressure**
8. **The friction loss, on the liquid being moved, in pipes, valves and equipment in the system is called ________ head.**
9. **The ratio of luminous flux emitted by a lamp to the power consumed by the lamp is called_________________.**
10. **In an amorphous core distribution transformer, ______ loss is less than a conventional transformer**

ANS:

1 Best efficiency point / pump operating point/ duty point
2. Load curve
3. Apparent Power
4. Isothermal efficiency
5. Thermal energy (or steam or waste heat or gas or any energy related to thermal energy)

6. Forward Curve
7. Static
8. Dynamic/friction head
9. uminous efficacy
10. No load

L-4 **A Cooling Tower cools 1565 m3/hr of water from 44º C to 37.6º C at 29.3º C wet bulb temperature. The cooling tower fan flow air rate is 989544 m^3/hr (air density = 1.08 kg/m^3) and operates at 2.7 cycles of concentration.**

Find

a) Range,
b) Approach,
c) % CT Effectiveness
d) L/G Ratio in kg/kg
e) Cooling Duty Handled in TR
f) Evaporation Losses in m^3/hr
g) Blow down requirement in m^3/hr
h) Make up water requirement/cell in m^3/hr

Ans:

*	CT Flow m^3/hr		=	1565 (1565000 kg/hr)
*	CT Fan Flow, m^3/hr		=	989544
*	CT Fan Flow kg/hr Density of 1.08 kg/m^3	@	=	1068708
d)	L/G Ratio of C.T. kg/kg		=	1.464
a)	CT Range		=	(44 – 37.6) = 6.4°C
b)	CT Approach		=	(37.6 – 29.3) = 8.3°C
c)	% CT Effectiveness		=	100 * [Range/Range + Approach]
			=	100 * (6.4) / (6.4 + 8.3)
			=	43.53
*				
e)	Cooling Duty Handled in kCal		=	1565 * 6.4 * 10^3
	(i.e., Flow * Temperature Difference in kCal/hr)		=	10016 * 10^3 kCal/hr / 3024
				3312 TR
f)	Evaporation Losses in m^3/hr		=	0.00085 x 1.8 x 1565 x 6.4
			=	15.32 m^3/hr
*	Percentage Evaporation Loss		=	[15.32/1565]*100

		=	0.98 %
g)	Blow down requirement for site COC of 2.7	=	Evaporation losses/COC–1
		=	15.32/(2.7–1) = 9 m^3/hr
h)	Make up water requirement in m^3/hr	=	Evaporation Loss + Blow down Loss
		=	15.32 + 9
		=	24.32

L-5 A free air delivery test was carried out before conducting a leakage test on a reciprocating air compressor in an engineering industry and following were the observations:

Receiver capacity	**:**	**10 m^3**
Initial pressure	**:**	**0.2 kg / cm^2g**
Final pressure	**:**	**7.0 kg / cm^2g**
Additional hold-up volume	**:**	**0.2 m^3**
Atmospheric pressure	**:**	**1.026 kg / cm^2 abs.**
Compressor pump-up time	**:**	**4.0 minutes**

The following was observed during the conduct of leakage test during the lunch time when no pneumatic equipment/ control valves were in operation:

a) **Compressor on load time is 30 seconds and unloading pressure is 7 kg/cm^2g**

b) **Average power drawn by the compressor during loading is 90 kW**

c) **compressor unload time and loading pressure are 70 seconds and 6.6 kg/cm^2 g respectively.**

Find out the following:

(i) Compressor output in m^3/hr(neglect temperature correction)
(ii) Specific Power Consumption, kW/ m^3/hr
(iii) % air leakage in the system
(iv) leakage quantity in m^3/hr
(v) power lost due to leakage

Ans.

(i)

Compressor output m^3/minute :
$$\frac{(P_2 - P_1) \times \text{Total Volume}}{\text{Atm. Pressure} \times \text{Pumpup time}}$$

: (7.0 - 0.2) x 10.2/ 1.026 x 4
= 16.9 m^3/minute
: 1014 m^3/hr

power consumption : 90 kW
output : 1014 m^3/hr

(ii)
Specific power consumption : 90/1014 = 0.08876 kW/m^3/hr

(iii) % Leakage in the system
Load time (T) : 30 secs.
Un load time (t) : 70 secs
% leakage in the system : $\frac{T}{(T+t)} x100$
: $\frac{30}{(30+70)} x100$
: 30%

iv) Leakage quantity : 0.30 x 1014
: 304.2 m^3/hr

v) Power lost due to leakage : Leakage quantity x specific power consumption

: 304.2 x 0.08876
: 27 kW

L-6 An energy audit of electricity bills of a process plant was conducted. The plant has a contract demand of 3000 kVA with the power supply company. The average maximum demand of the plant is 2300 kVA/month at a power factor of 0.95. The maximum demand is billed at the rate of Rs.500/kVA/month. The minimum billable maximum demand is 75 % of the contract demand. An incentive of 0.5 % reduction in energy charges component of electricity bill are provided for every 0.01 increase in power factor over and above 0.95. The average energy charge component of the electricity bill per month for the company is Rs.13 lakhs.

The plant decides to improve the power factor to unity. Determine the power factor capacitor kVAr required, annual reduction in maximum demand charges and energy charge component. What will be the simple payback period if the cost of power factor capacitors is Rs.800/kVAr.

Answer

kW drawn	2300 x 0.95 =

	2185 kW
Kvar required to improve power factor from 0.95 to 1	kW (tan θ_1 – tan θ_2)
	kW (tan (cos$^{-}\theta_1$) – tan (cos$^{-}\theta_2$)
	2185 (tan (cos^{-}□□□□) – tan (cos^{-}□)
	2185(0.329 - 0)
	719 kVAr
Cost of capacitors @Rs.800/kVAr	Rs.5,75,200
Maximum demand at unity power factor	2185/1 = 2185 kVA
75 % of contract demand	3000x0.75=2250 kVA
Reduction in Demand charges	2300-2250=50kVa, as the plant has to pay MD charges on minimum billable demand of 2250, and not on the improved MD of 2185 kVA in this case
	50kVA/month x 12 months x Rs.500 kVA/ month= Rs.3,00,000
Percentage reduction in energy charge from 0.95 to 1 @ 0.5 % for every 0.01 increase	2.5 %
Monthly energy cost component of the bill	Rs.13,00,000
Reduction in energy cost component	13,00,000 x (2.5/100)
	Rs.32,500/month
Annual reduction	Rs.32,500 x 12
	Rs.3,90,000
Savings in electricty bill	Rs.6,90,000
Investment	Rs.5,75,200
Payback period	5,75,200/ 6,90,000
	0.83 years or 10 months

……. End of Section – III …………….