**REGULAR** **Paper 3 – Set B**

**Regn No: _____**

**Name : _____**
**(To be written by the candidate)**

**17th NATIONAL CERTIFICATION EXAMINATION**
**FOR**
**ENERGY MANAGERS & ENERGY AUDITORS – September, 2016**

**PAPER – 3: Energy Efficiency in Electrical Utilities**

**Date: 25.09.2016 Timings: 0930-1230 HRS Duration: 3 HRS**

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

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**Section – I: OBJECTIVE TYP**

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| 1. | Which of the following power plants has the highest efficiency<br>a. **Combined cycle gas turbine**<br>b. Diesel Engine<br>c. Conventional coal plants<br>d. Open cycle Gas Turbine |
| 2. | Which of the following is wrong with respect to Color Rendering Index (CRI)?<br>a) The CRI is expressed in a relative scale ranging from 0 - 100<br>b) CRI indicates how perceived colors match actual colors<br>**c) CRI of Sodium Vapour lamp is much higher than that of a normal Incandescent Lamp**<br>d) The higher the color rendering index, the less color shift or distortion occurs |
| 3. | Which of the following is wrong with reference to heat rate of a coal fired thermal power plant ?<br>a) Heat rate indicates the overall energy efficiency of a power plant<br>b) When calculating plant heat rate, the energy input to the system is GCV of the fuel<br>c) Lower the heat rate the better<br>**d) 860 kCal per kWh is practically achievable** |
| 4. | Which of the following is wrong statement with reference to LED lamps? |

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| | a) LED lamps are as energy efficient as CFL bulbs or better.<br>b) LED lampas are more durable than CFLs<br>c) LED lamps has no hazardous material like mercury<br>**d) LED lamps are not suitable for Street Lighting purpose** |
| 5. | Which of the following is the most comfortable conditions for an office room?<br>DBT = Dry bulb temperature, and RH = Relative humidity<br><br>a) 20°C DBT and 80% RH<br>b) 26°C DBT and 100% RH<br>c) 15°C DBT and 30% RH<br>**d) 25°C DBT and 55% RH** |
| 6. | Which of the following devices do not produce any harmonics?<br>a. Electric Motors<br>**b. Filament Lamp**<br>c. Switch Mode power supply of laptops<br>d. Electromagnetic ballasts |
| 7. | Which of the following cannot be controlled by automatic power factor controllers<br><br>a) **KW** b) voltage c) Power factor d) KiloVAr |
| 8. | Which of the following can be attributed to Commercial Loss in Electrical Distribution System?<br>a) Lengthy Low Voltage Lines b) Low Load side power factor<br>**c) Faulty consumer service meters** d) Undersized conductors |
| 9. | Which Loss in a Distribution Transformer is predominant if the transformer is loaded to75% of its rated capacity?<br>a) core loss<br>b) **copper loss**<br>c) hysteresis loss<br>d) magnetic field loss |
| 10. | *The voltage unbalance in three phase supply is 1.5 %. If the motor is operating at 100 $^{o}$C, the additional temperature rise in $^{o}$C due to voltage unbalance is*<br><br>*a.* **4.5** b. 9 c. 0 d none of the above |
| 11. | The term “cooling range” in a cooling tower refers to the difference in the temperature of<br><br>a) dry bulb and wet bulb<br>b) hot water entering the tower and the wet bulb temperature of the surrounding air.<br>c) cold water leaving the tower and the wet bulb temperature of the surrounding air.<br>d) **hot water entering the tower and the cooled water leaving the tower**. |
| 12. | 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<br>**a) 74.4** b) 64.5 c) 261.6 d) none of the above |

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| 13. | The power factor of a synchronous motor<br><br>**a) Improves with increase in excitation and may even become leading at high excitations**<br>b) Decreases with increase in excitation<br>c) Is independent of its excitation |
| 14. | The percentage reduction in distribution loses when tail end power factor is raised from 0.8 to 0.95 is:<br>a**) 29%** b) 15.8% c) 71% d) 84% |
| 15. | The parameter used in Star labeling of air conditioner is<br>a. COP **b. EER** c. KW/TR d. EPI |
| 16. | The no-load loss and copper loss of a 500 kVA transformer is 900 watts and 6400 watts respectively. What is the total loss at 50% of transformer loading?<br><br>a) 4100 watts<br>b) 6850 watts<br>**c) 2500 watts**<br>d) 3650 watts |
| 17. | A good DG set waste heat recovery device manufacturer will take precautions to prevent which of the following problem while DG set is in operation<br><br>a) voltage unbalance on generator **b) Excessiveback pressure on engine**<br><br>c) excessive steam generation d) turbulence in exhaust gases |
| 18. | The kVA reduction by improving the power factor of a plant operating at 400 kW load from 0.85 to 0.95 is<br>a) 40 b) **49** c) 72 d) None of the above |
| 19. | The formation of frost on cooling coils in a refrigerator:<br><br>a) improves C.O.P. of the system<br>b) increases heat transfer<br>c) reduces power consumption<br>**d) increases power consumption** |
| 20. | The effect of increasing the air gap in an induction motor will increase:<br><br>a) power factor<br>b) speed<br>c) capacity<br>d) **magnetizing current** |

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| 21. | The distinction between fans and blowers is based on<br><br>a) impeller diameter<br>**b) specific ratio**<br>c) speed<br>d) volume delivered |
| 22. | The blow down requirement in $m^3$/hr of a cooling tower with evaporation rate of 16 $m^3$/hr and CoC of 3 is<br><br>a) 4 b) 2 c) **8** d ) 16 |
| 23. | The basic function of an air dryer in a compressor is to<br><br>a) Prevent dust from entering the compressor<br>b) Remove moisture before the intercooler<br>c) Remove moisture in compressor suction<br>**d) Remove moisture at the downstream of the after-cooler** |
| 24. | Shunt capacitors connection is normally adopted for:<br>a. Distribution Voltage improvement.<br>b. Power factor improvement.<br>c. **Both a and b**.<br>d. None of these |
| 25. | Power factor is highest in case of<br>a. Sodium vapour lamps<br>b. Mercury vapour lamps<br><br>c. Tube Lights<br><br>d. **Incandescent lamps** |
| 26. | Kg of moisture / kg of dry air is defined as<br>**a) Absolute humidity**<br>b) Relative humidity<br>c) Variable humidity<br>**d)** Dew Point |
| 27. | Installing larger diameter pipe in pumping system results in reduction in:<br><br>a) Static head<br>**b) Dynamic head**<br>c) Both (a) and (b)<br>d) None of the above |
| 28. | Increasing the impeller diameter in a pump<br>**a. Increases the flow**<br>b. decreases the head |

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| | c. decreases the power<br>d. all of the above |
| 29. | In no load test of a poly-phase induction motor, the measured power by the wattmeter consists of:<br><br>a) core loss<br>b) copper loss<br>c) core loss, windage & friction loss<br>**d) stator copper loss, iron loss, windage & friction loss** |
| 30. | In electrical power system, transmission efficiency increases as<br><br>**a) both voltage and power factor increase**<br>b) both voltage and power factor decrease<br>c) voltage increases but power factor decreases<br>d) voltage decreases but power factor increases. |
| 31. | In a Three Phase Transformer, the secondary side line current is 139.1A, and secondary voltage is 415V. The rating of the transformer would be _____.<br>a. 50 kVA<br>b. 150 kVA<br>**c. 100 kVA**<br>d. 63 kVA |
| 32. | In a refrigeration system, the expansion device is connected between the<br><br>a. Compressor and condenser<br>b. Condenser and receiver<br>c. Condenser and evaporator<br>d. Evaporator and compressor |
| 33. | In a lithium bromide absorption refrigeration system<br><br>a. lithium bromide is used as a refrigerant and water as an absorbent<br><br>**b. water is used as a refrigerant and lithium bromide as an absorbent**<br><br>c. ammonia is used as a refrigerant and lithium bromide as an absorbent<br><br>d. none of these |
| 34. | In a DG set, the generator is consuming 70 litre per hour diesel oil. If the specific fuel consumption of this DG set is 0.33litres/ kWh at that load, what is the kVA loading of the set at 0.8 PF?<br>a) 212 kVA **b) 262.5 kVA** c) 170 kVA d) None of these. |
| 35. | If EER of One Ton Split AC unit is 3.51, what is its power rating?<br>a) **1.0 kW** |

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| | b) 1.5 kW<br>c) 0.8 kW<br>d) 2.0 kW |
| 36. | For a supply end Voltage of 10.6 kV and receiving end Voltage of 9.8 kV, the percentage regulation works out to:<br>a) 0.80 **b) 8.16** c) 7.55 d) None of these. |
| 37. | Find the air density at 35$^{o}$C temperature at one atmospheric pressure. It is given that at one atmospheric pressure the air density at 20 $^{o}$C is 1.2041 kg/m$^{3}$<br>**a) 1.1455** b) 1.2657 c) 1.2024 d) none of the above |
| 38. | Energy Star Label Rating scheme for Fluorescent lamp is based on:<br>**a) Lumens per Watt at 100, 2000 and 3500 hours of use**<br>b) End of Lamp Life in terms of burring hours<br>c) Lumen depreciation at 2000 hours<br>d) Color Rendering Index |
| 39. | At which of the following discharge pressures, the same reciprocating air compressor will consume maximum power<br>a) 3 bar b) 5 kgf/cm$^{2}$ c) **90 psi** d) 500 kPa |
| 40. | As per the Inverse Square Law of illumination what will be the illuminance at half the distance?<br>a) 50% **b) 4 times** c) double d)No change |
| 41. | As per the building area method given in Energy Conservation Building Code (ECBC) compute the lighting power allowance; given that : the allowed LPD is 12 watt per square meter and enclosed office area is 500 square meter<br>**a) 6 kW**<br>b) 4.16 kW<br>c) 6 W<br>d) 4.16 W |
| 42. | As per Energy Conservation Building Code compute the Effective Aperture (EA); given that Window Wall Ratio (WWR) is 0.40 and Visible Light Transmittance(VLT) is 0.25<br>**a) 0.10**<br>b) 0.65<br>c) 0.33<br>d) 0.15 |
| 43. | An Induction motor rated 15 kW and 90 % efficiency, at full load will:<br>a) Draw 15 kW b) Draw 13.5 kW c) Deliver 16.66 kW d) **Deliver 15 kW** |
| 44. | A spark ignition engine is used for firing which type of fuels:<br>a) high speed diesel<br>b) light diesel oil<br>**c) natural gas** |

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| | d) furnace oil |
| 45. | A DG set has a 300 HP engine drive and is connected to a 300 kVA alternator with 95% efficiency. When a plant load of 290 amps at 415 Volts and 0.76 power factor is connected, the engine loading works out to<br><br>a) 52% **b) 74.51%** c) 55.4 % d) None of the above |
| 46. | A company installed a new 100 kVAr, 415Volt capacitor but the power analyzer indicates that it is operating at 93 kVAr. The reason could be<br><br>a. Operation is at low load<br>b. Higher Voltage at terminals<br>c. **Lower voltage at terminals**<br>d. None of the above |
| 47. | A better indicator for cooling tower performance is<br><br>a) Heat load in tower<br>b) Range<br>c) RH of air leaving cooling tower<br>**d) Approach** |
| 48. | A 50 hp motor with a full load efficiency of 90 percent was found to be operating at 25 kW input. The percent Motor Load is<br>a) 75% b) 67% c)**60%** d) 25% |
| 49. | A 4 pole 50 Hz induction motor is running at 1470 rpm. What is the slip value?<br><br>a) 0.2<br>**b) 0.02**<br>c) 0.04<br>d) 0.4 |
| 50. | A 10 MVA generator has power factor 0.86 lagging. The reactive power produced will be<br><br>a) 10 MVAr<br>b) 8 MVAr<br>**c) 5 MVAr**<br>d) 1.34 MVAr. |

***……. End of Section – I ……..…..***

## Section – II: SHORT DESCRIPTIVE QUESTIONS

**S-1** Explain how a Variable Frequency Drive saves power in a three phase electric motor driven pumping system? What will be the reduction in power drawn by a motor by reducing the speed by half?

**Ans**

The VFD converts a basic fixed-frequency, fixed voltage sine-wave power (line power) to a variable frequency, variable-voltage output used to control speed of induction motors.
By controlling speed of a pump rather than controlling flow through use of throttling valves, energy savings can be substantial.

By affinity law, if the speed of the pumping is reduced by 1/2, the power drawn by the motor will be reduced by a factor of eight (1/2)3 = 1/8.Using a fixed speed motor would require some type of mechanical throttling device, such as a vane or damper; but the fact remains that the motor would running full load and almost full speed (full power), dropping the pressure across the flow control device.

**S-2** Match the following Terms in ECBC

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| 1 | Lighting Power Density (LPD) | A | Rate of Heat Flow in Watt per square meter per degree Centigrade |
| 2 | Energy Performance Index (EPI) of a building | B | Light admitting potential of a Glazing System |
| 3 | Effective Aperture(EA) | C | Watts per square meter |
| 4 | Visible Light Transmittance (VLT) | D | kWh per square meter per year |
| 5 | U-Factor | E | Ratio of Light Passing through glazing to the light passing through perfectly transmissive glazing |

**Ans :** **1,C; 2,D; 3,E; 4,B; 5,A**

**S-3** State three advantages of improvement of Power Factor at Load side
Power Factor at the load side is 0.75 and average minimum load is 100 kW. What is the kVAr rating of capacitor to improve the Power Factor at the load side to 0.95 ?

**Ans.**

Advantages of Power Factor improvement.
a) Reduced kVA (Maximum demand) charges in utility bill
b) Reduced distribution losses (KWH) within the plant network
c) Better voltage at motor terminals and improved performance of motors

Capacitor required to improve Pf from 0.75 to 0.95 for an Average Load of 100 kW
= 100{tan ($\cos^{-1}$ 0.75) - tan ($\cos^{-1}$ 0.95)} = 100(0.882-0.329) = 55.3 kVAr, say 55 kVAr

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| | ***Or***<br><br>$kVAr_{Old} = \sqrt{(kVA_{old}^2 - kW^2)} = \sqrt{(100/0.75)^2 - 100^2} = 87.67$ kVAr<br><br>$kVAr_{new} = \sqrt{(kVA_{new}^2 - kW^2)} = \sqrt{(100/0.95)^2 - 100^2} = 32.86$ kVAr<br>Additional kVAr required = 87.67-32.86 = 54.76 kVAr, say 55 kVAr |
| S-4 | List five energy saving measures in a commercial building. |
| Ans | • Optimize air conditioning volumes by measures such as use of false ceiling and segregation of critical areas for air conditioning by providing partitions.<br><br>• Reduction in solar heat gain through building envelope by providing efficient glazing.<br>• Use of energy efficient lighting systems<br>• Using occupancy/ motion/ sound sensors for lighting system<br>• Use of energy efficient pumping systems<br>• Use of energy efficient air conditioning systems<br>• Providing efficient barriers for avoiding hot air leakage into cold spaces.<br>• Optimizing evaporator temperature to $22^0$C<br>• Avoiding use of heating appliance in cool spaces. |
| S-5 | One unit of electricity in end-use application is equivalent to about two units of electricity generated. Substantiate your answer with the computation of cascade efficiency from generating plant ex-bus to end-use application.<br>Assume: Efficiency of Generator yard substation as 98%; transmission and Distribution Loss = 19%; Efficiency of End-use application= 60% |
| Ans | Cascade efficiency from ex-bus generator to end-use =<br>Efficiency of Generator yard substation x Efficiency of transmission and Distribution x Efficiency of End-use application<br>Which is approximately = 0.98x(1-0.19)x0.60 = 0.476<br><br>Therefore one unit at end use application = [1/0.476] = 2.09 Units, say 2 Units at ex-generator bus |
| S-6 | A 415 V, 15kW, 3-ph, 50Hz Induction motor operates at full load, with 88% efficiency and 0.85 power factor lagging:<br>a) Find the current drawn by the motor<br>b) If this motor is replaced by 92 % energy efficient motor with 0.91 power factor, what will be the power savings in terms of k W and kVA? |

Ans

a). $kW_{in}$ (Input power) = 15 / 0.88 = 17.05 kW
Line current = 17.050 / (√3 x 0.415 x 0.85) = 27.91 Amp
$kVA_{in}$ = 17.05/0.85=20.06 kVA OR (√3 x 415X27.91)

b) For the same output of 15 k W
Input power with 92.0 % efficiency will be = 15/0.920 = 16.3 k W and
k VA at 0.91 power factor will be =16.216 /0.91= 17.82 or 18 k VA

Therefore, saving will be 17.05 -16.3 = 0.75 k W
and 20.06-17.82= 2.24 k VA

S-7

A performance analysis of a DG set was carried out. The following are the data obtained.

- Period of trial – 2 hrs
- Energy generated -1500 kWh
- Level difference in diesel day tank – 51.6 cm
- Diameter of day tank – 1m
- Calorific value of fuel -10500 kcals/kg

The air drawn by the DG set is 30 kg/kg of fuel. The energy auditor recommended for a waste heat recovery system. Also the auditor indicated waste heat recovery potential is $2.6x10^5$ kcal/hr if the flue gas temperature after waste heat recovery system is maintained at $185^0$C.

a) Calculate the average efficiency of DG set and its specific fuel consumption

b) Calculate present flue gas exit temperature if specific gravity of fired fuel oil of 0.86 and specific heat of flue gas is 0.25 kcal/kg 0C.

Ans

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| 1 | Fuel consumption (litres) during 2 hrs of trail period {(area x height diff) of day tank} ={3.14x($1^2$)/4 x0.516x1000)lit | 405 lit | |
| 2 | Specific gravity of fuel oil (given) | 0.86 | |
| 3 | Oil consumption in (kg/hr) (405x 0.86 / 2) | 174.18 kg/hr or 202.5 lit/hr | |
| 4 | Specific fuel consumption (kWh/lit) ( **Ans a**) | 3.7 kWh/lit or 4.3 kWh/kg | |
| 5 | Air supplied per kg of fuel (kg) (given) | 30 | |
| 6 | Mass of flue gas (Sl.No.5)+1kg | 31 | |
| 7 | Mass of flue gas kg per hour (Sl.No 6 x Sl.No 3) | 5399.5 | |
| 8 | waste heat recovery potential kCal/hr (given) | 260000 | |
| 9 | Delta T across waste heat recovery system (Heat kCal/hr)/(mass of flue gas/hr*specific heat) | 192.61 | |

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| | 10 | Exit flue gas temp. after waste heat recovery system (given) | 185 | | |
| | 11 | Present Flue gas temp. or temp. before waste heat recovery system ($185^0$C+Delta T) ( **Ans b**) | 377.6 | | |
| | 12 | Efficiency of DG set {750x860/(174.18x10500)} ( **Ans a**) | =35.3 | | |
| S-8 | a. The rated compressor capacity is 14.25 $m^3$/min. Evaluate if there is any capacity de-rating using the air- receiver tank filling method conducted at shop floor. The relevant data is given below.<br><br>Volume of Air receiver including pipe and cooler = 9 $m^3$<br>Initial Pressure = 0.5 kg/$cm^2$<br>Final Pressure = 7.0 kg/ $cm^2$<br>Atmosphere pressure= 1.026 kg/ $cm^2$<br>Time taken to build up the pressure = 5 minutes<br><br>b. What is the deficiency in this calculation and how can it be corrected ?. | | | | |
| | a) Compressor output from tank filling method<br>= [(7.0-0.5) x9/ (1.026x5)] = 11.40 $m^3$/min<br>Capacity shortfall = 14.25-11.40 = 2.85 $m^3$/min,<br>i.e., (2.85/14.25)x100 = 20% capacity de-rating<br><br>b) The above calculation assumes the compression is isothermal. It can be corrected by introducing the temperature correction factor: $(273+T_2)$ /$(273+T_1)$ where $T_1$ is suction Temperature and $T_2$ is receiver temperature. | | | | |

***……..…… End of Section - II ……..…….***

**Section – III: LONG DESCRIPTIVE QUESTIONS**

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| L-1 | **State true or false ( 1 marks each)**<br>1. The efficiency of gas turbine power plant is lower than that of a combined cycle power plant.( **T** )<br>2. The performance of air compressor at high altitudes will be lower as compared to that at sea level(**T**).<br>3. Efficiency of transformer will be minimum when copper loss is equal to iron losses. ( **F**)<br>4. In cooling towers, the water droplets entrapped in the air stream is captured by drift eliminators.( **T**)<br>5. To get the static pressure, the inner and outer tubes of pitot tube are connected to manometer.(**F**)<br>6. The throttling of pump discharge will change the pump characteristic curve (**F**).<br>7. The simplest way to reduce the discharge from a reciprocating air compressor is to throttle it. (**F**)<br>8. Cycle of Concentration (COC) is the ratio of dissolved solids in circulating water to the dissolved solids in makeupwater(**T**)<br>9. Use of VFD will save power but also create harmonics.(**T**)<br>10. The synchronous speed of a 4 pole motor will be 3000 rpm (**F**) |
| L-2 | An air supply system with belt driven centrifugal fan and necessary damper adjustment has a flow rate of 12 $m^3$/s. One branch of the system, having a flow of 1.5 $m^3$/s, require static pressure of 89 mmWC.<br>Although, the remainder of the system could operate at 66 mmWC, the fan is operated at 89 mmWC to provide for pressure required by the branch. The system operates for 5000 hours /year<br>Energy auditor proposes to reduce the fan speed to reduce the static pressure to 66 mmWC and provide a booster fan in the duct to deliver 89 mmWC static pressure to the branch. The speed reduction is proposed to be achieved by changing the fan pulley diameter. The motor and fan efficiencies remain same after pulley change.<br>Booster fan has an efficiency of 75% and drive motor of 85% efficiency.<br><br>Measured motor input power to main supply fan = 16.2 kW<br><br>Fan data:<br>Initial fan speed = 1200 rpm<br>Initial motor pulley diameter = 209 mm<br>Initial fan pulley diameter = 305 mm<br>hours of operation = 5000 |
| Ans | Revised fan speed = 1200 x (66/89) ^0.5<br>= 1031 rpm<br>New fan pulley diameter = 305 x 1200/1031= 355 mm |

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| | Initial ideal fan power = 12 x 89/102 = 10.5 kW<br>Revised ideal fan power = 12 x 66/102 = 7.8 kW<br>Initial motor input power = 16.2 kW<br>Revised motor input power = 16.2 x 7.8/10.5 = 12 kW<br>Annual energy savings = (16.2-12) x 5000 = 21,000 kWh<br>Annual cost savings = 21000 x Rs.7/kWh = Rs.1,47,000/-<br><br>Booster fan flow rate = 1.5 m3/s<br>Static pressure = (89-66)= 23mmWC<br>Ideal fan power = 1.5 x 23/102 = 0.34 kW<br>Fan shaft power = 0.34/0.75 = 0.45 kW<br>Drive motor capacity = 0.45 / 0.85 = 0.53 kW<br><br>Annual energy consumption of booster fan<br>= 0.53 x 5000 = 2650 kWh<br>Annual cost savings = 2650 x 7 = Rs.18550/-<br><br>Net savings = 1,47,000 – 18,550 = Rs. 1,28,450/- |
| L-3 | A centrifugal water pump operates at 70 $m^3$/hr and at 1470 RPM. The pump operating efficiency is 70% and motor efficiency is 89%. The discharge pressure gauge shows 3.4 kg/$cm^2$. The suction is 3 m below the pump centerline.<br>An energy auditor recommends to replace the existing motor with a four pole motor of 91% efficiency and a slip of 1% . Determine the new flow rate and the power drawn by the motor.<br>In both the cases the throttle valve is fully open and system head is purely frictional.<br><br>Comment on the measure. |
| Ans | **Existing**<br>Flow = 70 $m^3$/hr<br>Head developed by the pump = 34 – (-3) = 37 m<br>Power drawn by the pump = (70/3600) x 37 x 1000 x 9.81/(1000 x 0.70)<br>= 10.1 kW<br><br>**Proposed**<br>Speed of the pump with new motor = 1500- [(1/100)x1500] =1485 RPM<br>Flow rate of new pump with increase in RPM<br>Q1 /Q2 = N1/N2<br>Q2 = Q1 x (N2/N1) = 70 x (1485/1470) = 70.71$m^3$/hr<br><br>Power drawn by the pump with new motor = 10.1 x $(1485/1470)^3$ = 10.4 kW<br>Power drawn by the existing motor =10.1/0.89 = 11.35 kW<br>Power drawn by the new motor = 10.4/0.91 = 11.43 kW<br><br>Comment<br>Comment-1: Power consumption is more , so not recommended<br>(or) |

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| | Comment-2: Power consumption is more however flow is also more. |
| L-4 | a) A Residential colony having a fixed load of 300 KVA is situated 1 km away from a 3 phase, 11 kV / 415 V transformer from which the power is to be fed. The management is evaluating the choice of LT (1 run x 3.5 core x 300sqmm) Vs HT (1 run x 3 core x 70sqmm) distribution for a 1 km stretch. Given the following data, as a n energy auditor what would you suggest and estimate the payback period on marginal investment (difference in the two investments)<br>b) Support your recommendation with calculations.<br>c) Data<br>d) • Total Resistance of LT cable (conductor cross section 300sqmm)is 0.13 ohms / km and the cost is Rs 700/m<br>e) • Total Resistance of HT cable(conductor cross section 70sqmm) is 0.570 ohms / km and the cost is Rs 1300/ m<br>f) • Unit price is Rs 6.5 / kWh<br>g) • Cost of relocating the transformer (in case of HT cabling ) = Rs 1 lakh<br>Add voltage regulations loss (single run x root 3) |
| | Soln<br>Resistance of LT cable is 0.13 ohms / km and the cost is Rs 700/m<br>Resistance of HT cable is 0.570 ohms / km and the cost is Rs 1300/ m<br><br>Current drawn in LT system = 300/(0.415*1.732) = 417.37 A<br><br>Current drawn in HT system = 300 /(1.732*11) = 15.74 A<br><br>Power loss in LT system =( $(417.37)^2$x 0.13 x 1 x 3ph)/1000 = 67.93 kW<br><br>Power loss in HT system = ( $(15.74)^2$x 0.57 x 1 x 3ph)/1000 = 0.42 kW<br><br>Energy saving on account of conversion from LT to HT line = 67.93 – 0.42 = 67.51 kW<br><br>Annual energy savings = 67.51 x 8760 = 5,91,387.6 kWh<br><br>Annual cost savings = 5,91,387.6 x 6.5 = Rs 38,44,019/-<br><br>Investment required for laying HT cable supply = Rs 1300 x 1000 = 13,00,000/-<br>Investment required for relocating transformer = Rs.1,00,000<br>Total Investment required for laying HT cable supply and relocating transformer<br>= (13,00,000+1,00,000)<br>= Rs.14,00,000<br><br>Investment required for laying LT cable supply = Rs 700 x 1000 = Rs. 7,00,000/- |

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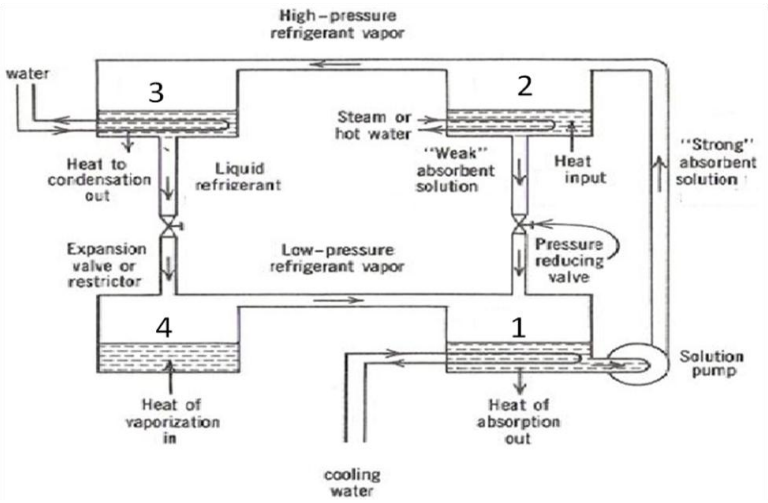
|---|---|
| | Pay back for the marginal investment = (14,00,000 – 7,00,000 ) / 38,44,019<br>= 0.18 yrs = 3 months |
| L-5 | A 1680 $m^3$/hr reciprocating compressor is operated by a 160 kW rated motor with an efficiency of 87% and is drawing 159 kW. The actual requirement of the compressed air is increased by 100 m3/hr due to an additional equipment. Plant is considering to increase the speed of the compressor to meet this marginal requirement by modifying the compressor pulley size. The existing speed and pulley sizes are given below.<br>o Motor rpm : 1400<br>o Motor pulley diameter : 300mm<br>o Compressor rpm : 700 rpm<br>o Compressor Pulley diameter : 600 mm<br>Find out the new pulley diameter and also the additional power consumption after increasing the speed?<br>Based on the calculation check whether the motor has the capacity to handle the additional load. |
| Ans | Initial flow rate = 1680$m^3$/hr<br>Modified flow rate = (1680 + 100) = 1780 $m^3$/hr<br><br>Initial rpm = 700 rpm<br>Modified rpm = (1780 /1680 ) x 700 = 742 rpm<br><br>Modified, compressor - pulley size = using the expression $N_1D_1 = N_2D_2$<br>$D_2 = N_1D_1/N_2$ = (700x600)/742 = 566 mm<br><br>Modified motor power consumption = (742 / 700) x 159 kW = 168.54 kW<br><br>Capability of the motor = 160 kW / 0.87 = 183.9 kW<br><br>Hence the motor have the margin to absorb the additional load of 100 $m^3$/hr |
| L-6 | Identify the type of refrigeration system depicted in the following figure and also the components represented by 1,2,3 &4 . Explain briefly the function of each of these components. |




Vapor Absorbtion Refrigeration system

1. Absorber : Concentrated LiBr absorbs the refrigerant vapor (water) and becomes dilute.

2. Generator : Heats the dilute LiBr refrigerant, regenerates refrigerant (water vapor ) and also concentrates LiBr.

3. Condensor: Condenses the regenerated refrigerant (water vapor)

4. Evaporator : Liquid refrigerant (water) in atomised form picksup the heat from the cooling chilled water coil and becomes water vapor.

***-------- End of Section - III -----***