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Energy Audit - Optimization of Energy Losses and Load Management of Textile Industry in Pakistan

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Abstract: Energy is one of the main arguments in favor of evaluating the procedure, promotion, and presence of the world. Energy audit and conservation is important for the natural and economic progress of developing countries such as Pakistan. In this research work, energy audit and load management were carried out for efficient energy utilization in industrial processes. Energy audit conducted in the spinning unit of Nishat textile industry proved beneficial in realizing efficient utilization of energy along with reduction in energy waste. A detailed comparison of newly installed and rewound induction motors, air compressor systems, and lighting systems was performed. Energy utilization of rewound induction motors, using BEST energy saving software, and lighting was also analyzed. Upon completion of the energy audit total annual electrical energy 31,983. MWh utilization was reduced to 30,462. MWh. After energy audit annual 4.75% MWh per annum electrical energy saved was proposed to be saved. This energy audit will ensure the minimization of cost factor, improved efficiency, proper management of operating load, and energy losses in the audited textile industry.

Key words: Electrical energy saving

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1. Introduction

Industrial energy audits have increased in the past years due to the pressure caused by high power prices and the transition towards a sustainable future. Energy consumption is a big cost item for commercial businesses in the long run and the increase in energy prices is growing, the value of energy audits is rising, and more energy-saving firms and organizations are starting to pay attention to energy audits. As the energy audit of the day plays a great role in the effective utilization of energy, the Government of Pakistan is also paying head towards its effectiveness by considering energy audit while planning its policies. The textile sector of Pakistan is one of the largest sectors and contributes 67% of exports, 10.2% of the gross domestic product (GDP), and 46% of the total manufacturing, and it employs 40% of the labor force. Hence, it is the best growing industry in Pakistan, which makes exploring this industry essential. Regarding quantity, the Pakistani textile sector exports achieved a positive trend of 13.08% in terms of value at the end of FY-2018 while it was 12.83% in FY-2017 Thus, this textile sector is considered to be the best sector in terms of job creation and economic growth (Safeer et al., 2019). Other major industries include cement, fertilizer, edible oil, sugar, steel, tobacco, chemicals, machinery and food processing. Energy balance is the need of the hour due to high energy demand of the industry. The use of the energy balance, actual energy demand and losses can be determined properly, which is crucial for energy saving, load handling and economic development of industries

Electricity is flood of electrical charge or power. It is both the basic component of nature and one of the most broadly used form of energy. Electricity is basically a derived source of energy which is referred to an energy carrier (Iqbal, Mahmood, & Akhtar, 2017). It means that electricity is generated by the change of some other source of energy such as from coal, solar energy and nuclear energy. These are also called main sources. The sources of energy we use to generate electricity may be non-renewable or renewable. Electricity offers a variety of ranges of commonly known effects such as electromagnetic induction, electrical current, lightning and static electricity (Mills, 2012). Electricity today is the most significant energy form for small, medium and large businesses. Electrical energy is now one of the latest discoveries those have changed entirely the daily life of almost every person on this planet. Everyone is now playing with this energy all the time. The importance of electricity can be judged from the fact that this is now our basic need. This is the component of today’s modern technology and we cannot perform our daily activities without it. Traditionally developed economic theories represent just labor and capital as the most essential elements of every manufacturing industry (Iqbal, Mahmood, & Akhtar, 2017).

Energy audit is helpful for improvement in technology and electric energy savings (Schleich, 2009). There are various uses of electricity in an industry such as lighting, rotating, cooling, heating, and electrical power supply. Most industries use a wide range of quantities of electric power for their specialized system. The total quantity of electrical power consumption contributes to the quantity of the system. It depends on the production demand, type of equipment being utilized, and also the time of year. The finest method to reduce electricity utilization in the industry is to perform an energy audit (Yaacob & Zina, 1993). An energy audit is important to calculate equipment's efficiency and estimate energy consumption to identify savings occasions (Ozturk et al., 2016).

An energy audit is a very simple method that tells us regarding the electrical energy utilization methods in anyone industry. Energy audit teaches us about the quantity and cost of many forms of energy and explains which sort of energy is used in different processes and goods that are essential to the tasks of generating utility (Tleppaev, 2016). A large number of motors are used in the textile industry. Whenever the windings of these motors are burnt, the industrialists rewind and use the motors, which reduced the efficiency of the motors and increased the losses (Singh & Gupta, 2011). Energy efficiency plays an important tool in the company's strategy to meet global challenges (Worrell & Galitsky, 2004). The major electrical energy utilization in buildings is the lighting and air conditioning system. Lighting systems consumes approximately 25% of electrical energy utilization in buildings. The lighting system used in buildings mainly utilizes T8 fluorescent lamp tubes of 18W and 36W and the conventional inefficient high power magnetic ballasts. The main energy waste in a building is the attitude of organization staff not switching off lighting when not required to be in operation in buildings. The use of efficiently designed lighting technology can reduce equipment energy losses with improved lifespan and lighting quality (Bhawarkar & Kamdi, 2011). Air conditioning consumes the highest electrical energy in buildings. The energy conservation on air conditioning system identified the following energy inefficiency and wastes in the split unit air conditioning system (He, Long, Zhou, & Zhao, 2009).

The energy audit offers a balance between energy production and energy consumption and also indicates areas where energy is waste, and the amount of energy used. Industrial Energy Audit is a suitable tool to view and keep track of the enormous energy management programs (Bhagavathy, Latha, & Elango, 2018). Hence, they are 75% of total load use are three-phase induction motor and 12 % use lighting and other systems.

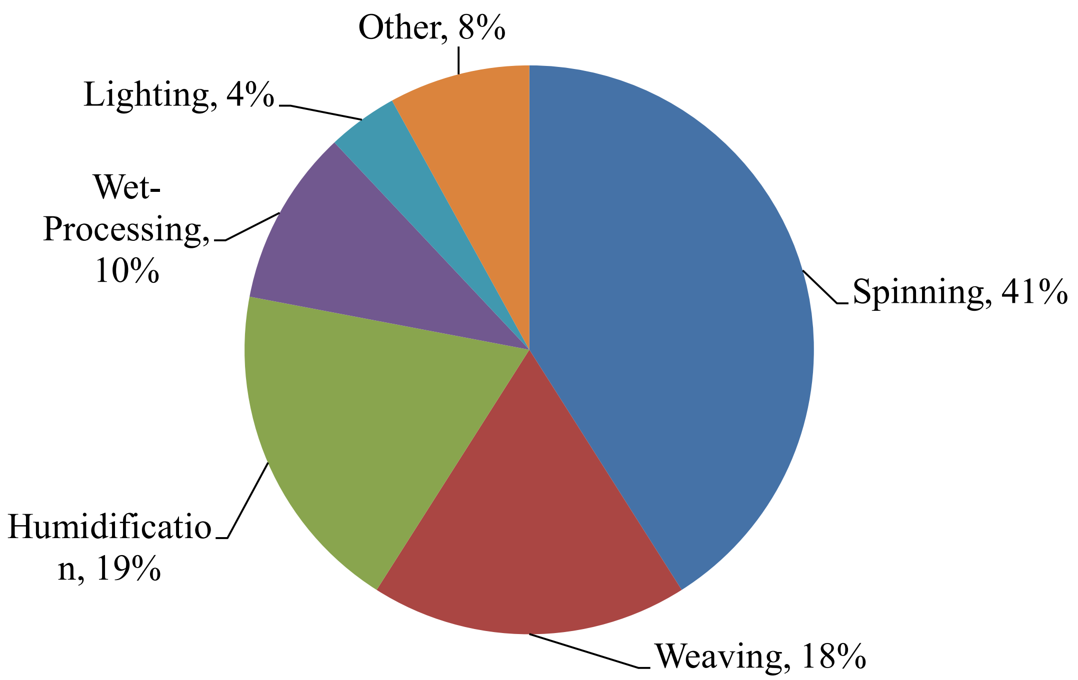

Figure 1 Power map of a composite (Rajput & Singh, 2016)

We can perform an energy audit and minimize losses to reduce production costs. Old and high-energy loads will be replaced by efficient and advanced equipment. This audit will improve the overall economic and production growth of the industry, which will show a vital part in the development of the nation.

1.1 Scope of the Study

This project was split into two phases: preparing for an energy audit and inspection of the facility. The first step involved organizing a checklist, holding meetings with the staff and the management. The second step constituted of presentation and introduction to energy-saving options. With the help of audit analyzed of expenses and profits.

2. Energy Audit Three Phase Rewound Induction Motors

A large number of motors are used in the textile industry. Whenever the winding of induction motors was burnt, industry rewinds its and used this motors. This rewound motor reduces the efficiency and increases the losses. It was also noted up to two and three time rewinds the same motor efficiency more decreased respectively. Therefore, it is suggested to check the efficiency of the motor after each rewind and it is necessary to replace it with an efficient motor (Rajput et al., 2014). Figure 2 depicts a flow chart for comparing two motors.

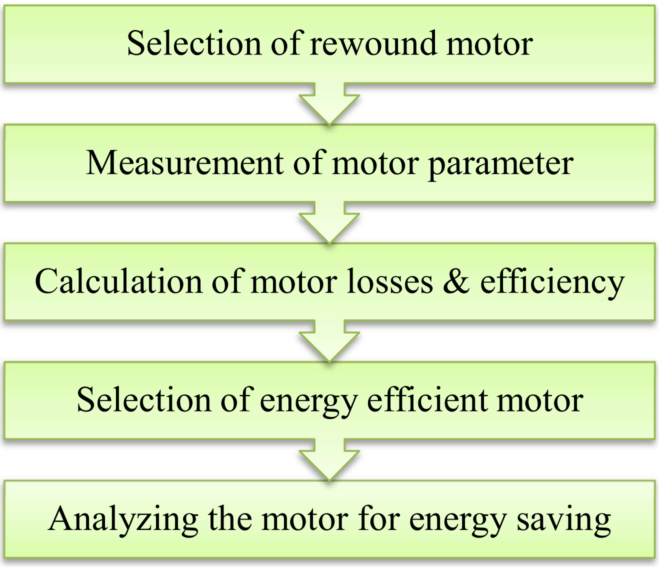

Figure 2 Flow chart of comparing motors (Rajput and Singh , 2016)

The BEST Baldor Energy Savings Tool is a software program that compares the efficiency and annual electricity usage of your existing motors. The program then calculates the annual potential savings and provides an estimated payback calculation and suggests replacement of motors to make upgrades easier.

2.1 BEST energy saving software

The software analyses the efficiency and annual electricity consumption of users' existing motors, and calculates the cost savings that can be achieved by replacing them with equivalent higher-efficiency models. Built-in motor performance and pricing information enables the software to suggest optimum replacements and to estimate the investment payback period. BEST energy saving software will prove useful to electrical engineers and maintenance personnel wishing to implement a comprehensive site-wide motor management strategy, or to compare the costs of a motor rewind against those of a replacement motor. The software is also helpful for anyone charged with conducting an energy audit of their company. The required input data and output from the software can be seen from figures 3 and 4 respectively.

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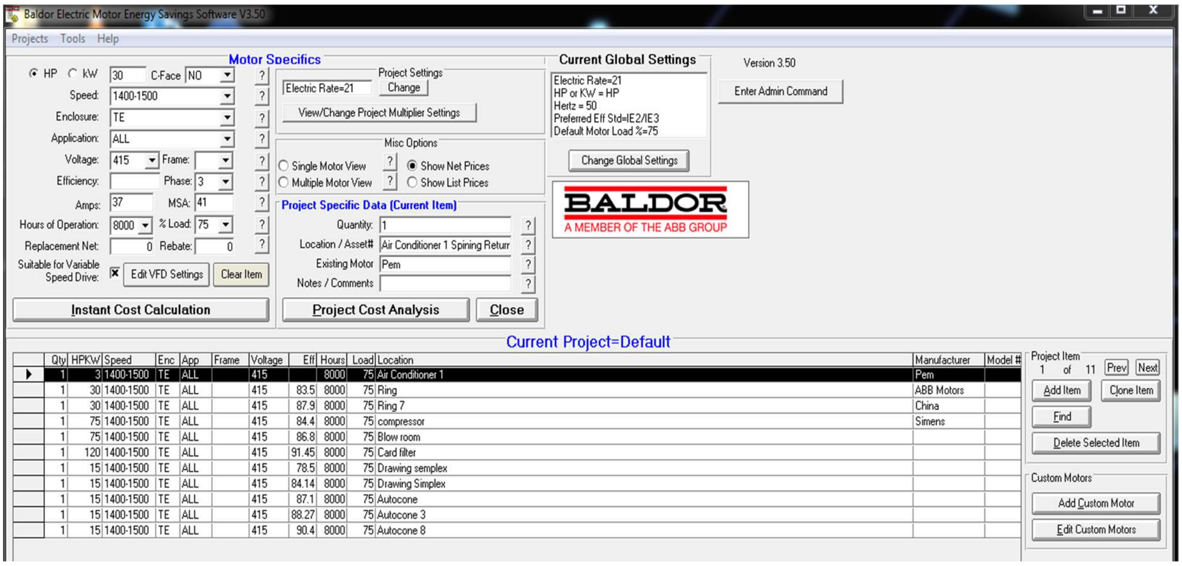

Figure 3 Software require Data

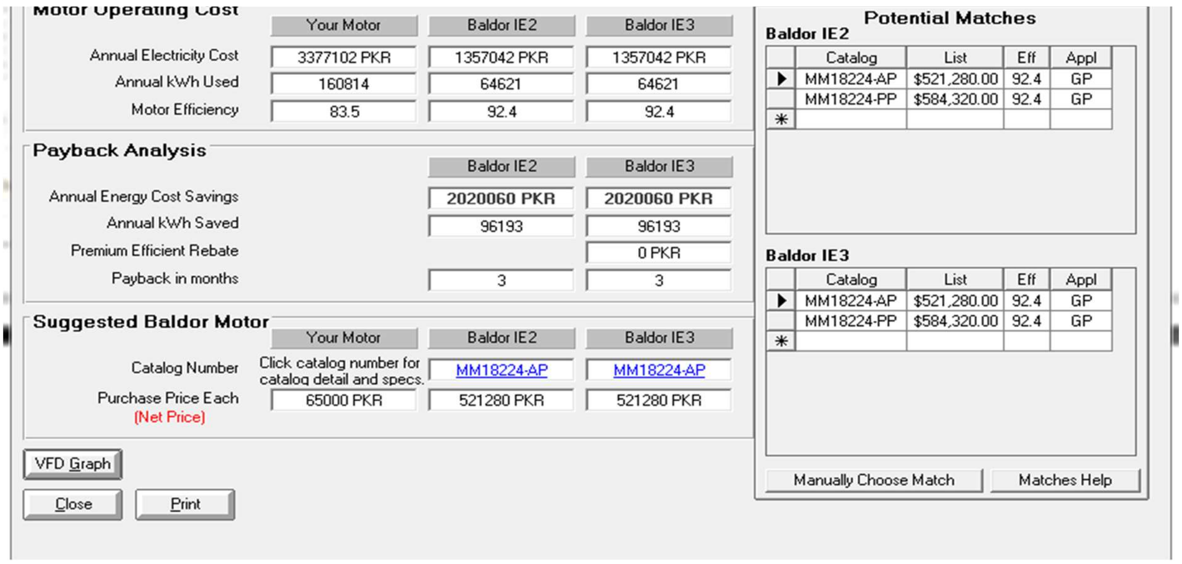

Figure 4 Analyze Cost and payback time

Clicking on the Instant Cost Calculation button shows the amount of energy being used by the existing motor, together with the amount that would be used by comparable Baldor Standard-E (IEC IE2 rated or NEMA Energy Efficient) and Super-E (IEC IE3 or NEMA Premium Efficient) models. The results screen also shows the purchase cost of the motors and the payback period, and provides a direct link to a full motor specification. A built-in report writer function facilitates the creation of a simple summary or detailed report, with an export feature allowing the results to be output to an Excel file for further analysis or archiving.

Table 1 Input data for BEST energy software

HP	Speed (RPM)	Enclosure	Application	Voltage	Frame	Efficiency %	Phase	Hrs./ Yr.	Amps	% Motor Load	Measured Amps	Repair Cost	Qty.	Location/Asset #
15	1400-1500	TE	All	415	NA	78.5	3	8000	18	75%	24	35000	1	Drawing Simplex
15	1400-1500	TE	All	415	NA	84.14	3	8000	18	75%	22	35000	1	Drawing Simplex
15	1400-1500	TE	All	415	NA	87.1	3	8000	18	75%	24	35000	1	Autocone
15	1400-1500	TE	All	415	NA	88.27	3	8000	19	75%	24	35000	1	Autocone
30	1400-1500	TE	All	415	NA	79.1	3	8000	37	75%	41	65000	1	Air Conditioner
30	1400-1500	TE	All	415	NA	83.5	3	8000	37	75%	44	65000	1	Ring
30	1400-1500	TE	All	415	NA	87.9	3	8000	38	75%	42	65000	1	Ring 7
75	1400-1500	TE	All	415	NA	84.4	3	8000	80	75%	89	100000	1	Compressor
75	1400-1500	TE	All	415	NA	86.8	3	8000	80	75%	87	100000	1	Blow Room
120	1400-1500	TE	All	415	NA	91.45	3	8000	105	75%	117	130000	1	Card Filter

Table 2 Output data from BEST energy software

Status	Replacement IE3/IE3 catalog	Payback Months IE2/IE3	Annual cost Your Motor	Annual Cost IE2/ IE3	Annual kWh Your Motor	Annual kWh IE2/ IE3	kWh Saved IE2/IE3	Annual Saving IE2/IE3	Price Motor IE2/IE3	Efficiency % Motor IE2/IE3
Processed	MM16114-AP	3	1796102	693532	85528	33025	52503	1102570	294720	90.4
Processed	MM16114-AP	3	1675707	693532	79795	33025	46770	982175	294720	90.4
Processed	MM16114-AP	3	1618760	693532	77083	33025	44058	925228	294720	90.4
Processed	MM16114-AP	3	1597304	693532	76062	33025	43037	903772	294720	90.4
Processed	MM18224-AP	2	3564956	1357042	169759	64621	105138	2207914	521280	92.4
Processed	MM18224-AP	3	3377102	1357042	160814	64621	96193	2020060	521280	92.4
Processed	MM18224-AP	3	3208055	1357042	152764	64621	88143	1851013	521280	92.4
Processed	MM25554-AP	3	8352725	3320727	397748	158129	239619	5031998	1204480	94.4
Processed	MM25554-AP	3	8121774	3320727	386751	158129	228622	4801047	1204480	94.4
Processed	MM28904-PP	3	12334084	5296332	587337	252206	335131	7037752	1909440	94.7

Due to BEST energy software calculate every rewound motors annual Kwh losse, calculate payback time and suggested of replacement new energy saving motors.

Total Annual Kwh save= 1279214

3. Energy Audit Lighting Systems in Textile

The clothing sector naturally needs sufficient lighting for operators to use the fabric quality, basting (sewing), and defects. In this regard, we can observe a switch to control the power, wiring, light fittings, fixture, factory hall wall, room shape, etc. Lighting can be turned off for non-operating hours utilizing automatic switches such as residence sensors that turn off the lighting when a room becomes uninhabited. In addition to automatic controls, physical switches can also be used to save extra energy in smaller spaces. The development of EEMs is carried out

with the aid of energy recorders to determine real energy utilization of the Lighting and Air Conditioning systems. Electrical energy audit carried out in an organization can be a low cost simple audit to develop low cost measures or a detailed audit which can develop medium and high cost EEMs but is costly and time consuming. The audit process will identify energy losses and wastes in the building and to develop the EEMs (Wang, Huang, & Cao, 2010). And for this annual energy saving must change old high consumption light replace to new technology base LED.

Table 3 Use Light Quantity

Light	Watt	Quantity	Total kW
T8 Fluorescent Tube light bulb	32	275	8800
Led tube light	20	940	18800
Led Tube Light	12	350	4200
Street light	80	43	3480

Tube light T8 Fluorescent annual KWh use in 8000h per year

Used energy (KWh) = number of light x watt of the light x working hours/1000

= (275 x 32W x 8000 hr/year)/1000

= 70,400 kWh/year

Annual Energy Cost = annual KWh use × Cost per kWh

= 70400 × 21

= Rs 1478400/-

The Energy Can Be Saved By Adding a 12W LED Tube Fitting Instead of a T8. Fluorescents Lamp Fitting.

Annual working hours = 8000

Used energy (kWh) = Number of light x Watt of the light x Working hours/1000

= (275 x 12W x 8000 hr/year)/1000

= 26400 kWh/year

Annual Energy Cost = Annual kWh use × Cost per kWh

= 26400 × 21

= Rs 554400/-

Annual Saving Coast = 1478400 – 554400

= Rs 924000/-

Table 4 Annual Saving After Replacement Tube

Lights	Watt	Annual use kWh	Annual Cost R.s	Replace 12w LED tube Use then kWh annual	Annual Cost after Replace
T8 Fluorescent Tube Light	32	70,400	1478400	26400	554400
Led tube light	20	150400	3158400	90240	1895040
Led tube Light	12	33600	705600	33600	70560
Total		**254400**	**5342400/-**	**150240**	**3155040/-**

Annual Saving Energy = 104160

Annual saving cost = Rs 2187360/-

Replace 32 w and 20w to (1215) 12w Led tube one tube net price Rs 700/-

Payback time = 0.38 year

Energy audit was conducting of light system of textile industry. Due to old and high wattage light, electricity consumption is very high. Replacing the old light system with a 12W LED will save Rs 2187360 per year. This system will be much better for the industry and will also avoid wastage of energy.

After replace led tube then lighting load convert or shifting to Renewable source solar photovoltaic

System approximate 19 KW lighting load installed 20 kW PV system

Price of 20kW PV system = Rs 1900000/-

Payback time PV system = 1.2 year

After installed PV system annual lighting load system saving = Rs 3155040/-

3.1 Power Consumption of Street Light

Annual working hours = 4380

$$\text{Used energy (KWh)} = \text{number of light} \times \text{watt of the light} \times \frac{\text{working hours}}{1000}$$

= (43x 80W x 4380 hr/year)/1000

= 15067 KWh/year

$$\text{Annual Energy Cost} = \text{annual kwh use} \times \text{cost pr kwh}$$

= 15067 × 21 rupees

= 316407 R.s

4. Recommendations

After Replacement Street Light to 60W LED Calculate Saving Energy and Cost Estimation

For the solar lighting system consisting of 43 street lights of 60 W each.

Total watt = 60 × 43 =2580 watt

= 2.58 kW

Considering 12 hours light operation = 2.58 × 12

=30.96 kWh per day

For 365 day in a year = 30.96 × 365

=11300.4 kWh

Per year Cost of 1 kWh = Rs 21/-

Annual cost = Rs 237308/-

Total energy expenses of the mill on street light in year for solar lighting =NIL

Per year saving in energy cost = (316407 – 0) = Rs. 316407/-

Considering the estimated life of the solar system for at least 10 yr.

The total saving in energy cost = Rs. 3164070/-

The price of solar LED streetlight of 60 wattages is = Rs.11,500 /-

But the price of scrape (old street light system) is =Rs. 1,000 /-

Net price of solar street light will be = (11500-1000) = Rs.10500/-

Total number of street light require=43

Total price of street light =43 × 10500

= Rs 451500/-

We have to also include some extra Cost for this extra arrangement (Rs.1500/-)

= 43 ×1500 =Rs.64500/-

Total cost on solar system for 1st year =451500 + 64500

=Rs.516000/-

Payback period = (516000 x 12 / 3164070)

= 2 month

This payback period is considering the life of the solar system only for 10 years, not for 25 years.

5. Calculate Energy Losses of Air Compressor Systems

The compressor is one of the most important parts of electrical energy consumption. Compressed air is known as industry's fourth utility and the motors that power these air compressors are typically industrial plants' single largest user of electricity. If inefficiencies exist in a compressed air system, there is a great opportunity to reduce energy expense with minimal effort and investment (Koski, 2002). Compressor losses occure due to these various factors, including; leakage, installation of the duct connection point, motor efficiency, compression stage, pressure, operation, and maintenance.

Table 5 Types of Compressor Used

Sr No	Compressor	Working Pressure	Maximum Pressure	Free Air delivery	Noise level	The energy lost due to leakage/day	Per day loss Rupees
1	Compressor 1 (55kw)	8 Bar	9 Bar	14.7 m^3/min	69 dB	188 kWh	3948
2	Compressor 2 (55kw)	8 Bar	9 Bar	13.88 m^3/min	69 dB	215 kWh	4515
3	Compressor 3 (37kw)	8 Bar	8.5 Bar	5.40 m^3/min	75 dB	129 kWh	2709
						532 kWh	Total=Rs11172/-

5.1 Compressor 1

T = Load on time in minutes = 3 min

t = Unload on time minutes = 7.5

Q = 14.7 (m^3/min)

a) Leakage quantity $(m^3/minutes), q = \frac{3}{3+7.5} \times 14.7$

$= 4.2\ m^3$/ min

b) Quantity of Leakage per day (m^3/day) = 4.2 ×12×60 = 3024 (m^3/day)

c) Compressed specific power for

air generation = 55 kW / (14.7×60) m^3/hr

= 0.0623

d) Energy lost due to leakage / day = 0.0623 ×3024 = 188 kWh

Per kWh rate =Rs 21/-

After auditing the energy of the compressor system, the daily energy losses due to compressor leakage are 532 kWh. If Compressor working 230 Day per year accrue 122360kWh Losses. In order to reduce these losses, the leakage of the compressor has to be controlled.

Controlled Compressor Losses

1. Leakage Findings
2. Line Moisture Separator and Traps
3. Compressed Air Filter

4. Regulators
5. Lubricators

6. Conclusion

The main goal of this research is energy-saving and textile load management. industry through an extensive energy audit. Energy expenditures are a major cost item for industrial companies and so the trend of energy costs is increasing with the increase in demand, most companies and relevant authorities are starting to pay due attention to energy conservation and energy audits. The energy audit carried out at Nishat's textile mills also aims to achieve the efficient consumption of energy and the reduction of energy waste. During conducting of the energy inspection or audit the main areas compulsory to take an energy-saving reduce energy bill cost for the reduction of energy due to energy wastage on Rewound induction motors and lighting were identified

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