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Automation of Mill Using PLC& Drives to Increase The Production, Energy Saving & Protection of Equipments

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ABSTRACT

The aim of this thesis work is to increase the production, energy saving & protection of equipments in a mill using PLC automation & drives. The mill Bharatam Tmt Bars Pvt. Ltd., Mandi Gobindgarh is going towards the danger of shutdown because of less production. For this work, a case study is done in which primarily all data regarding the reasons of faults in the mill responsible for the unnecessary shutdown for the year 2013-14 has been collected. Then before automation production of the mill has been calculated. On the basis of data collected, responsible factors by which the production of mill has been affected are analyzed. According to this analysis, automation has been done by using PLC to increase the production and protection of equipments. To achieve the objective of energy savings, data of different motors which are consuming high energy during daily production process has been collected. Production and performance of different equipments or motors before and after automation has been calculated and compared. Also production of the mill after automation has been calculated. Production of mill can be increased twice approximately and after automation of mill, approximately 20% of energy is saved and about 21% loading is reduced. Payback period and energy savings have been calculated.

Keywords: Thermo Mechanical Treatment (TMT), Programmable Logic Controller (PLC), Automation, Drives.

1. INTRODUCTION

In this fast improving and ever demanding world, industrial growth is also picking up the pace. All large scale industries can easily achieve the target of high production from the demanding customers but for small scale industries it is very difficult to run according to high demands of costumers by keeping in the mind that the costs of energy is increasing day by day. So, small scale industries or mill management must have to achieve some goals which include:

1. To increase the production of mill.
2. To increase the energy savings by keep in the mind the costs of energy.
3. To protect the mill equipments from faults and unwanted shut downs and also to maintain the overall setup for proper operations and continuous production.

If management is unable to achieve these goals it will results to shut down soon. To prevent the shutdown, mills are needed to upgrade conventional system into automatic system because all above mentioned goals can be achieved easily by using automation.

PLC and Drive was discovered to fulfill the requirements of Automotive Manufacturing Industry in America. Back in 1838, first drive was designed by B.S. Lakobi in Russia. In 1870 this drive was widely used in industrial applications. The proposal of hard wired electronic relay systems replacement was issued by GM Hydramatic in 1968. A memory was fixed in drive to store the program, user instructions and functions like on & off control, sequence of timing, arithmetic counting and data handling. Today it can be seen that theses drives, PLC and automation equipments are used in almost every application.

- **Need Of Automatic Control**

1. Automatically controlled system can provide long time protection to the transformer, motors and other electric equipments comparatively at low cost using less power.
2. Overloading conditions can be judged and prevented by automated system (sensors, PLC & drives).
3. High cost differential relays and other electromechanical relays can be replaced with the use of PLC logic control system.
4. Every information concerned with working equipments can be controlled in control room by operator to build up better strategy to manage and control different conditions.
5. Less manpower required which reduces human errors.
6. Automatic system reduces operational cost, maintenance and energy consumption.

- **What Is Automation?**

Automation is automatic operation of equipments such as machines, boilers, factory processes, heat ovens, stabilization of ships and steering, aircraft and other applications with reduced human efforts by using various control systems.
The benefit of using automation is that it saves energy, labour cost, material consumptions and also improve accuracy, process quality and precision. Before 1947, automation was not widely used. In 1930s feedback controllers were rapidly adopted by industry.
Automation achieved by various means including mechanical, pneumatic, hydraulic, electronic, electrical and computers were mostly in combination. Complicated systems, such as airplanes, ships and modern factories typically used all these combined techniques.

- **Energy Auditing: Principle And Its Objective**

It is a technique which is used to establish the pattern of energy use, identify how and where the losses are occurring and at which areas wastage of energy is more and then suggest appropriate economically engineering solutions to save the energy in the system. Principle of energy audit is the study of a process or a system and to reduce the consumption of energy while improving or maintaining human health and considering safety as primary concern. The objective of the energy audit is to determine & achieve the methods for optimum energy consumption and its utilization, throughout the organization to minimize energy costs/wastage without affecting production, quality and environmental effects.

2. STRUCTURE OF PROPOSED SYSTEM

A. Methodology used

To accomplish the objectives, following methodology canbeadopted:
1. Observed the overall production procedure of the mill and estimate the production at present conditions.
2. Collected the failure data of mill responsible for maximum shut down for year 2013-14.
3. On basis of data collected, factors affected the performance of the mill was analyzed.
4. On the basis of analysis, automation was done with the help of plc and drives, so as to reduce the faults and energy wastage of the equipments.
5. Production rate & performance of different equipments of the mill, before and after the automation was calculated & compared.
6. Payback period and energy saving was calculated.

B. Collected Data

1.Data of faults due transformer & motors

Table.1. Analysed factors causing shutdown due to motor faults

Motors		
S no.	**Name of faults**	**Shutdown period (in hrs)**
1.	Phase-phase winding short circuit	6
2.	Earth fault	12
3.	Overloading (temp. Rise)	36
4.	Supply fault	6

5.	Miscellaneous faults	2
6.	Bearing break	4
	Total shutdown hours in a year	**66**

From the observation of mill, it is estimated that shutdown of mill during the process due to some faults has been the major reason behind the low production of mill and data of faults is:

Table.2. Analyzed factors causing shutdown due to transformer faults

Transformer		
S no.	**Name of faults**	**Shutdown period (in hrs)**
1.	Temp. Rise	5
2.	Winding short circuit	24
3.	Oil leakage	3
	Total shutdown hours in a year	**32**

Table no. 1, 2 are showing the electrical faults of motors and transformer which are major cause of mill shutdown than other faults; hence electrical faults are taken up for analysis.

3. Data of Motors

Table.3. Rated data of motors

S no.	**Motor Applications**	**HP**	**KW**	**RPM**	**Rated Curr. Ir (A)**	**Efficiency (%)**
1.	Coal tank output	5	3.7	1140	7.5	89
2.	Conveyor	7.5	5.6	960	11.25	90
3.	Shear	20	15	1440	29.8	83
4.	Water pump	30	22	1440	43.5	87
5.	Coal tank input	40	30	1440	58.3	82
6.	TMT pump	60	45	2800	87.5	82
7.	Blower & APCD	75	56	1440	83.8	89.5
8.	Main motor 2	100	75	735	144.6	90.6
9.	Main motor 1	150	112	735	208.2	81

Table no. 3 is showing the rated data of motors which are playing major role to produce the total production of mill. Table is showing application of motors where they are working along with their HP, KW RPM, Rated current and Efficiency.

C. Automation for Electrical Faults

1. Transformer automation by PLC

Automation of transformer faults by using PLCis explained below:

- **Reduction of temp. Rise by control of cooling fans.**

When the flux of primary winding and secondary winding links with each other then heat is produced due to losses in the core. This heat is transferred to the winding of transformer and then to the oil of transformer. Transformer oil is provided in transformer for cooling and better insulation purpose. For cooling of transformer walls heat sinks are used. Heat is transferred to heat sink & no. of fans is connected in parallel to provide cooling to transformer walls. There is necessity to control them according to need, because temperature in night time and day time in summer session or in winter session are different. For automation purpose different type of heat sensors like Thermistor, Thermocouple, Optical sensors are used based on requirements. Output of sensor can be used as input of PLC and fans will operate according to output of PLC.

Fig.1. Transformer cooling fans

- PLC Control of Cooling Fans

PLC programming is done with Zelio Soft 2 software.

1. Input Z1 is the output of temperature sensor, CC1 is up counter which will continuously feed counted data in to the comparator V1. In any case temp. 20*C<Z_1<60* C then Q_1 output will energies, which will on selected fans.
2. In case temp. 60* C<Z_1<85* C then Q_2 will energies which will on more selected fans.
3. In case temperature 85* C<Z_1<95* C then Q_4 will energize which will turn on all fans and an alarm.
4. In case temp. Is more then 95* C then Q_4 will be energized and produce a trip signal to provide a safety for transformer in overheating conditions.
5. RC_1 is reset coil of counter CC_1 and Z_2 is reset input.

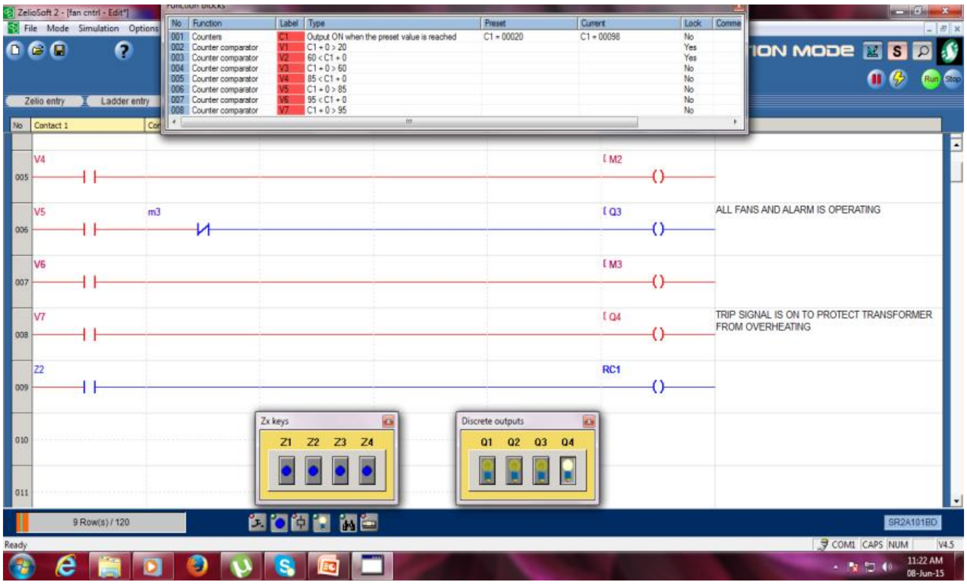

Fig.2. PLC programming of cooling fans

- **Oil Leakage Control using Pressure Sensor**

It is very important to find out any fault occurring in transformer due to leakage of oil. Basically it is done by measuring pressure inside the transformer. Measurement of pressure inside transformer is the basic principle for finding oil leakage in transformer. Using pressure sensor pressure inside the transformer can be easily measured. For automation purposes output of pressure sensor is Z_1 which is input to counter CC_1. If the value of pressure is equal to set value 5 in comparator then alarm Q_1 will get on. If value of pressure is further increasing and reaches equal or greater than 7 then trip signal Q_2 will be produced.

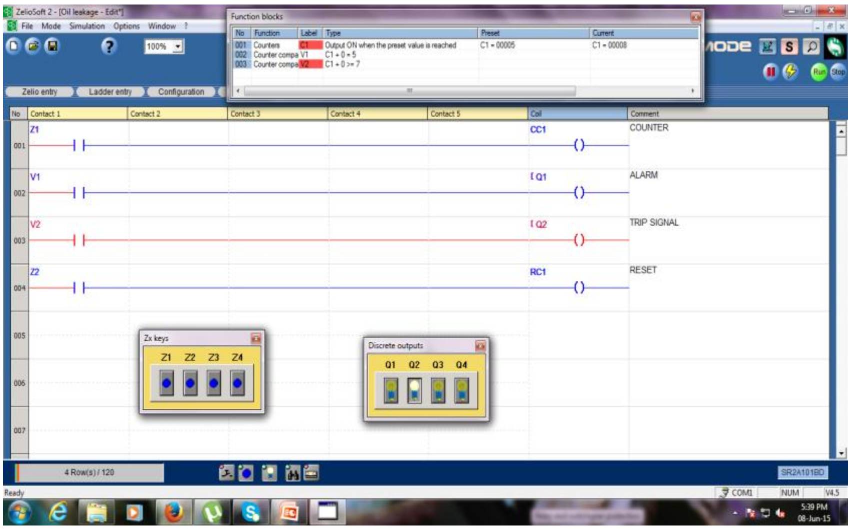

Fig.3. PLC programming of Pressure Sensor

2. Protection of motors using drives

In a mill motoring load is approximately 75-85 % of load is actually the motoring load out of the total mill load. Due to continuous operation motors has to run all the working hours without any rest and it is also necessary to run the motors without any fault during all working hours even when they are loaded or not loaded, which is not possible and also there is loss of energy thus their protection is also most important.

Table 4. Rated data of motors

S n	Applications	HP	KW	RPM	Ir (A)	Effi.
1.	Coal tank o/p	5	3.7	1140	7.5	89
2.	Conveyor	7.5	5.6	960	11.25	90
3.	Shear	20	15	1440	29.8	83
4.	Water pump	30	22	1440	43.5	87
5.	Coal tank i/p	40	30	1440	58.3	82
6.	TMT pump	60	45	2800	87.5	82
7.	Blower & APCD	75	56	1440	83.8	89.5
8.	Main motor 2	100	75	735	144.6	90.6
9.	Main motor 1	150	112	735	208.2	81

These motors play most important role during the operational hours to run continuously on load and no load conditions. No load conditions increases their maintenance, causes energy losses and faults. So there is need to protect them from faults and reduce energy losses by using drives.

A. Loading & energy consumption calculations of motors with-out using drives

Loading & energy consumption calculations of motors without using drives are shown below:

1. For 5 HP motor

Rated KW = 3.7
Rpm = 1440
Efficiency = 89%
Rated current (Ir) = 7.5A
Input current (Ii) = 5A
% loading = (Ii / Ir) x 100 = (5/7.5) x 100 = 66%
Actual loading = (kw x % loading / 100)= (3.7 x 66 / 100) = 2.44
Energy consumption / day = (actual loading / efficiency x 100 x total working hrs in a day)
= (2.44 / 89) x 100 x 8 = 21.93 KWH
Energy consumption / year = energy consu. / day x no. of working hrs in a year
= 21.93 x 310
= 6799 KWH
Similarly related data calculated for all motors

Table 5.Data calculated for all motors without using drives

S no.	HP	KW	Load current Ii (A)	% loading	Energy consumption / year (KWH)
1.	5	3.7	5	66	6799
2.	7.5	5.5	7.8	69	10468.7
3.	20	15	20.8	70	31373.5
4.	30	22	28.3	65	40763.2
5.	40	30	45.5	78	70773
6.	60	45	61.25	70	95268.3
7.	75	56	60.3	72	111724.7
8	100	75	108.5	75	153977
9.	150	112	150.7	72	246884
Total					768031.4

B. Production of mill before automation

The mill has been observed and estimated production has been calculated for one size of round steel which is as following:

- **For 8mm size**
  Weight of raw material = 120 kg (avg.)
  Weight of 8 mm diameter = 0.39 kg/m
  Length of 8 mm diameter = 120/0.39 = 308 m
  Speed of 8 mm diameter rolling = 6 m/sec
  Time taken to roll 1 piece = 308/6 = 51.3 sec
  No. of pieces rolled in 1hour = 3600/51.3 = 70 pieces

Production per hour = (no. of pieces in 1hr x weight of material x material efficiency x System efficiency)
= (70 x 120 x 0.8 x 0.96)/1000 = 6.46 tons/hr
Total production in a day (8 hrs) = 6.46 x 8= 51.68 tons/hr
Total production in a year = 310 x 50 = 15,500 tones

C. Loading, energy consumption, total energy saved &payback calculations of motors using drives

Loading, energy consumption, total energy saved & payback calculations of motors using drives are shown below:

1. For 5 HP motor

Input current (Ii) = 3.7A
% loading = (3.7 / 7.5) x 100 = 49.33%
Actual load on drive = kw x % loading / 100)
= (3.7 x 49.3 / 100) = 1.83
Energy consumption / day = (actual loading / efficiency x 100 x total working hrs in a day)
= (1.83 / 89) x 100 x 8 = 16.45 KWH
Energy consumption / year = energy consu. / day x no. of working hrs in a year
= 16.45 x 310= 5099.3 KWH
Total energy saved = (energy consu./year by motor) – (energy consu./year by motor using drive)
= 6799 – 5099.3 = 1699.7 KWH
Energy cost at Rs.7.35/unit = total energy saved x7.35
= 1699.7x7.35 = 12492.8 /-
Cost of drive = 37500 /-
Payback period = (cost of drive / energy cost per year)
= 37500 / 12492.8 = 3 years

Similarly data calculated for all motors

Table 6. Data calculated for all motors using Drives

S no.	HP	Drives	Load current Ii (A)	% loading	Energy consumption / year (KWH)
1.	5	ACS 150	3.7	49.3%	5099.3
2.	7.5	ACS 350	6.1	54%	8184
3.	20	ACS 350	15.9	53.34%	23907.2
4.	30	ACS 355	22.6	52%	32612
5.	40	ACS 550	36.4	62%	56253.6
6.	60	ACS 550	49.1	56%	76365.4
7.	75	ACS 850	47.2	56%	87284.9
8	100	ACS 850	89.6	62%	127286
9.	150	ACS 850	120.3	58%	198093.8
Total					615086.2

D. Production of mill after automation

After applying PLC on transformer and drives for the protection of motors. It is evaluated that shutdown periods of mill due to faults can be reduced hence rolling speed of mill can also be increased. The speed of rolling any particular size piece can be doubled as compared to speed before automation. Production of one piece having size is 8mm is shown below:

- **Production of 8mm size**
  Raw material = 120 kg (avg.)
  Weight of 8mm diameter = 0.39 kg/m
  Length of 8mm dia. = 120/0.39 = 308 m
  Speed of 8mm dia. Rolling = 12 m/sec
  Time taken to roll 1 piece = 308/12 = 25.6 sec
  No. of pieces rolled in 1 hour = 3600/25.6 = 140.6 pieces
  Production per hour = (140.6 x 120 x 0.8 x0.96)/1000 = 12.9 tons / hr
  Total production in a day (8 hrs) = 12.9 x 8= 103.2 tons / hr = approx. 100 tons / hr
  Total production in a year = 310 x 100 = 31,000 tones

4. RESULTS

Results of this paper are showing the production of mill, protection of equipments and energy consumptions before automation and after automation in the form of graphs below:

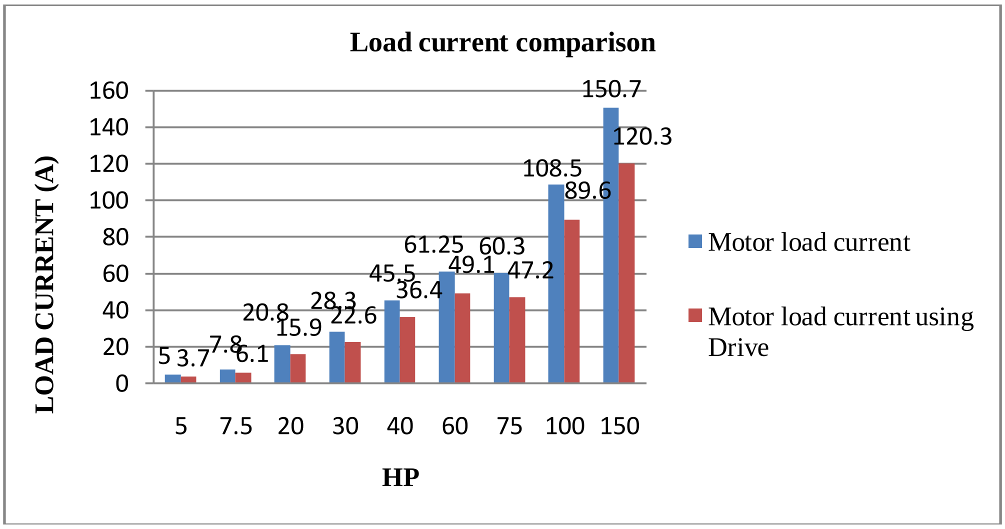

Fig. 4. Graph of load current vs. motors hp

From the above figure, it can be concluded that from 5 hp to 150 hp motors of the mill, using with drives are taking 19.9 % lesser load current than load current taken by motors using without drives.

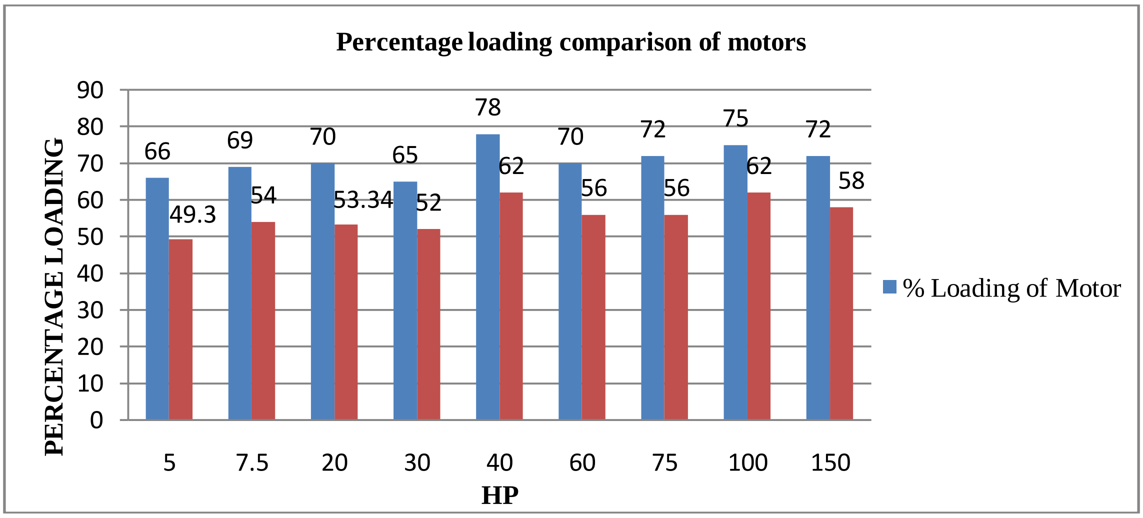

Fig. 5. Graph of percentage loading vs. motorshp

From the above figure, it can be concluded that from 5 hp to 150 hp motors of the mill, using with drives are taking 21 % lesser loading than loading taken by motors using without drives.

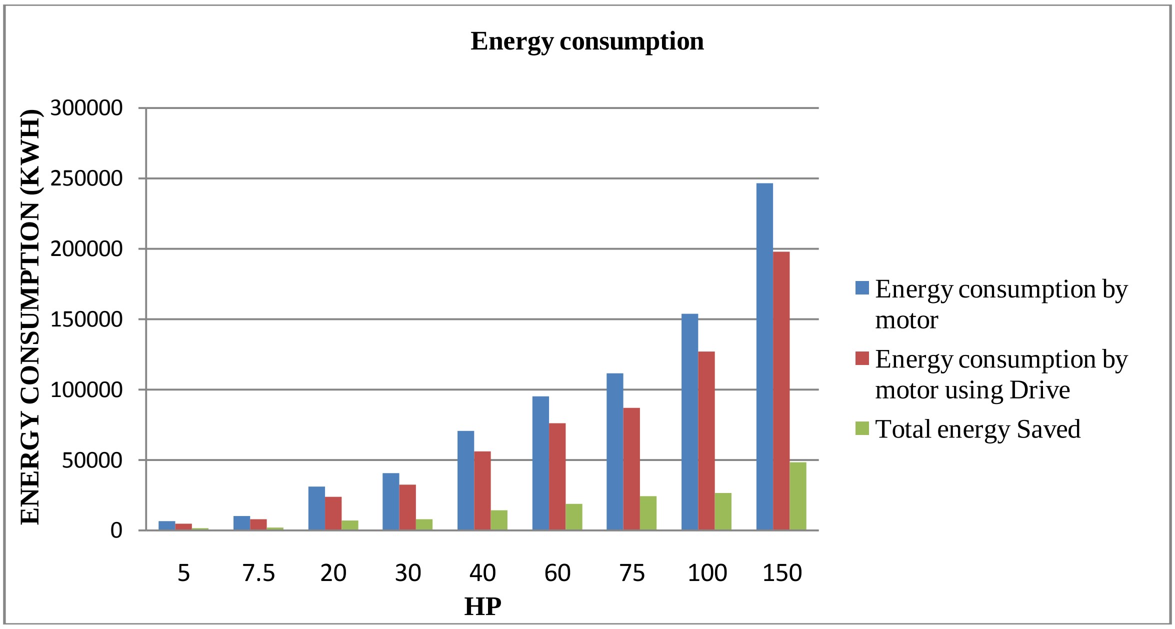

Fig. 6. Graph of energy consumption vs. motors hp

From the above figure, it can be concluded that from 5 hp to 150 hp motors of the mill, using with drives are consuming 20 % lesser energy than energy consumption by motors using without drives.

CONCLUSION

In this paper, methodology has been demonstrated to increase the production, protection from faults, energy saving and saving of money etc. To achieve this motive PLC and Drive automatic systems are used. The results have been compared with the previous results provided.

Results obtained from the study are briefly mentioned below:-

1. Automatic protection of equipments can reduce the mill shutdown period of mill, which results in increase of production & energy saving of mill.
2. Production of mill can be increased by approx.100 ton/day (2 times).
3. Protection of equipments& fast detection for any internal faulty condition.
4. Total energy saved = 768031.4 – 615086.2= 152945.2 KWH
5. Total Rs Saved/year = 152945.2 x 7.35 = 1124147.2 Rs
6. After automation total 20 % of mill energy can be saved.
7. After using drive system total 21 % loading of mill can be reduced.

FUTURE SCOPE

The following steps can be taken for the extension and modification purposes of industrial automation work:

1. In future SCADA system can be used for the protection of equipments which includes monitoring of transformer & checking the performance of motors and its maintenance.
2. By using HMI operational parameters can be changed directly from control room.
3. Automatic control components like sensors, encoders etc. can be used in mill as they will be very useful to sense the faults and to send protective signal to control room faster than electromechanical relays.
4. In future, tale breaker can be used to reduce the wastage of production by PLC automation.
5. Automatic control flying shear can be used as cutting tool.

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