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ENERGY- EFFICIENT SYSTEM FOR AC AND DC MOTORS

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Abstract- The need of energy conservation by the equipments is essential in all industries due to increase in cost of the energy. Similarly, increasing the productivity is desirable due to huge investments in large machinery. Power electronics along with the PLC has proven to have significant potential to improve the performance of equipments used in industries. In the process industries DC/ AC Drives of higher rating are used to drive the load. Once the capacity of main drive is decided, it is not possible to run these drives with increased demand of load. It reflects in the production limitation. All these drive motors are provided with external cooling arrangement. The cooling drive ratings are decided at design stage only. As per the maximum heat generated at 100 % load by the main Drive, These blower drives are running with full load irrespective of the heat generation. Hence they consume more power.

This research work introduces a new control philosophy by using combination of power electronics and PLC. The first part of work treats the issue of capacity enhancement of the main drive. The specially designed reference controller facilitates to increase the speed of auxiliary drive (blowers) for increasing the rate of cooling when load demand increases. The use of inverter duty motors in place of normal induction motors allows the increase in speed above its rated speed. This will enhance the cooling rate for the Main drive in such a way that main drive may accept the increased load demand without disturbing standard limits of drive.

The second part of the research work is aimed at the development of the application based PLC program to run the auxiliary drive based on the cooling unit design, temperature rise curve and current demand of the main drive. Process parameter, sequence controller will play major role in this section. Load curve analysis is required for fixing the speed reference parameters. A simple concept of step reference will give the reasonable power saving. This can be further optimized by using fuzzy controller. The first part will enhance the productivity by 15 -20 % while second part of the research work will save the energy in the normal operating condition (by enhancing the control of the auxiliary blowers) by 30 to 50 %.

Keywords- Load, No load, PLC, VFD, Sequence, Speed Reference control, SCADA.

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Introduction

Motor cooling system has been studied extensively during the past decades.

Many different cooling methods have been developed to achieve the following aims:

For a long period, [1] At the beginning motor self cooling system used, This cause the oversize of the motor, after further work on the cooling system size of the motor reduced for the same rating. [2] To reduced the size of the motor forced cooling system used this leads to the good improvement in the cooling of the motor and developed the drawback of increasing the power consumption.[3] Then water circulation system developed this lead in some extent to reduced the power consumption. Due to reduced in the size of blower. [4] Then further improvement done in the motor cooling system by using different fluids. This increased the motor cooling as well as efficiency of the motor and size of the motor reduced drastically. [5] In 2005 onward Inverter driven motor design and this change the entire scenario of the industries, Speed variation made easy by this. But at the lower speed motor over-heating problem arises.[6] In 2009 it was recommended to use external motor for cooling. This resolve the issue. But it doesn't provided the optimum solution for reducing the power consumption.

In all the above system it was observed that cooling of the motor good, but the power consumption more due to the unwanted cooling of the motor. Design of the cooling system has the limitation, It works satisfactory at the full load and lower speed, but at the lower speed and lower lower load it draws more power.

In this research work, I introduced the system which will optimize the cooling of the motor and reduce the power consumption in all speed and load range. To developed the system combination of PLC and Power electronics used.

Further to this the motor air circulation path modification and blower impeller angle modification to be taken into consideration. It was also discussed in this paper that external blower motor of the inverter driven load to be provided with speed control facility by using VFD and PLC.

Drive Reference modeling

Current formulation Model

The current feedback model based on the actual load on the respective stand motor which responsible for the heat generation. The model worked as a feedback to the PLC for generating speed reference for the blower motor. This model generated by using hardware like DC current transducer to generate (0- 10 V) as a feedback to the ABB PLC. This feedback compared with the set point for reference generation.

PLC Software Model

PLC software model development by using TIMER, COMPARATOR and MUX . This model release the speed reference to Blower VFD for controlling the speed of blower motor based on the mill Operating condition.

SCADA Model

SCADA developed for monitoring the current feedback to check the effectiveness of software and modification in software for reference generation if required.

Methodology

Proposed Scheme Block Diagram

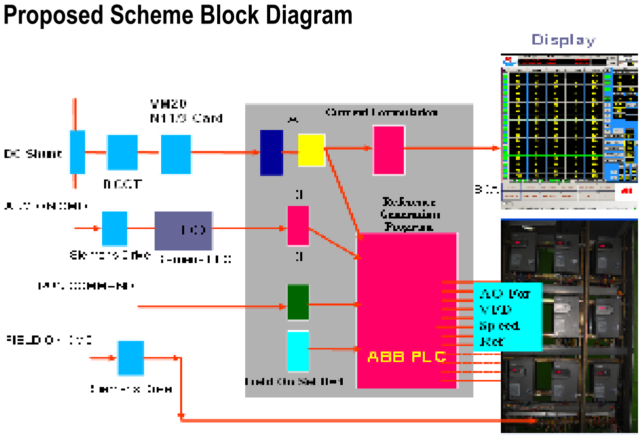

Fig. 1-

PLC program

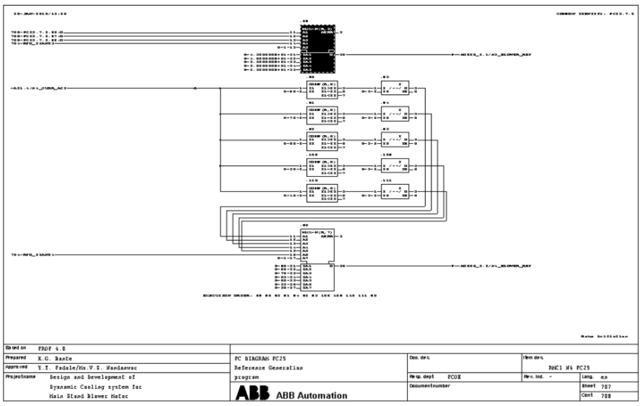

Fig. 2-

Control strategy

With the existing system blower are operated at full speed and consuming 100 % energy (i. e. Rated power of the motor) with the proposed system will change the speed according to the following logic.

Blower start -up method used

In the existing system blower start with full speed when aux ON command is given. With the proposed system blower will start with aux on but speed of the blower to be

kept at 50 % as the heat field current is 25 % only hence heat generation is less. This will save 70- 80 % energy.

Mill Ready for RUN.

In the existing system it is required to switch on the armature contactor so the field will fire at 100 % and drive is ready for run. With the proposed system drive ready signal will detected by PLC and 60 % reference is generated in this stage hence the blower will run at 60 % speed this will save 60- 75% energy.

Mill is running on No load.

Operator need to run the mill without load for taking mill trial. Also for small work he is not stopping the mill. Stopping the mill is not recommended for a small down time. With the new system when the mill is running 70 % reference generated for the blower hence it will run at 70 % speed. This will save 50 – 65 % energy.

Mill is on load.

With the proposed system when the motor takes the load it will monitor by the PLC and generate the speed reference from 75-100 % depends on the load. Load is categorized in groups 30-40 %, 40- 50%, 50- 60 %, 60- 80% and above 80 % for speed reference generation.

Development of PLC program for formulation of speed reference for the VFD

The task for the PLC program development is to release the reference from PLC at field on condition.

Formulation of the reference for VFD when the armature on command is given to main drive.

Formulation of the reference when the mill run command is given.

Formulation of the reference when the mill under load condition.

Signals used for logic development

- Field ON command
- Armature ON feedback .
- RFO
- Main Motor current feedback
- Motor Temperature feedback

PLC Block used for programming.

- Comparator Block
- Timer Block
- MUX Block
-

Comparator Block used to compare the actual load signal with the set load signal. This block monitor the actual signal and generate the output accordingly.

Timer Block used in the program for the smooth changeover of the reference to avoid the hunting of the VFD output and hence the speed of the motor.

MUX Block used to set the priority for the refrence release based on the mill operating condition. The feature of the card to release only one output at a time is the basic selection criteria of this block.

Evolution Method

Evaluational strategies are based on the comparison of the existing system with the proposed system by keeping the other parameters same in both the cases .The procedure starts by choosing one blower and checking its performance by conventional and non -conventional method

$$Powerconsumption=\sqrt{3}\ \ Il\ \ Vl\ \ PF$$

Actual power measurement in both the cases (i.e. DOL and drive with dynamic cooling system) Portable clampon energy meter used to take the reading section wise.

Calculation of breakdown time for the month

Mill discharge capacity 60 Billet/ Hr
consider 1 min dead time
Time recording of Stand 1 HMD de-energies to the time of HMD energies by real time clock of PC

Calculation for Mill running time for the month

= Total time – Mill breakdown time – Shut down time

Calculation for power saving

Psave – Power saving
Pccs – Power consumption with existing system
Pcps – Power consumption with proposed system

Calculation of Planned commercial down time for the month

- Planned size change time.
- Sample checking time.
- Billet soaking time for quality.
- Planned Maintenance shift.
- Raw Material (Billet) not available

Results and discussion

Results (Change in speed Reference)

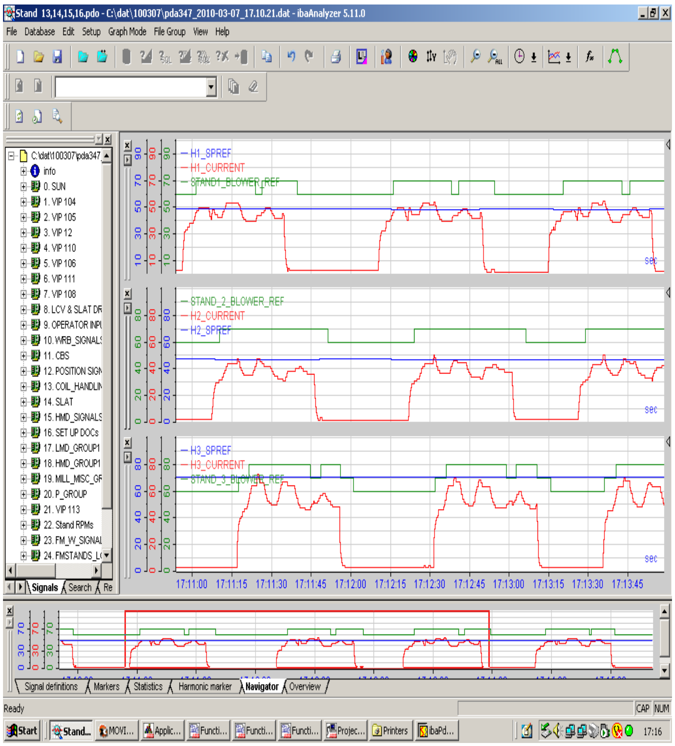

Fig. 3-

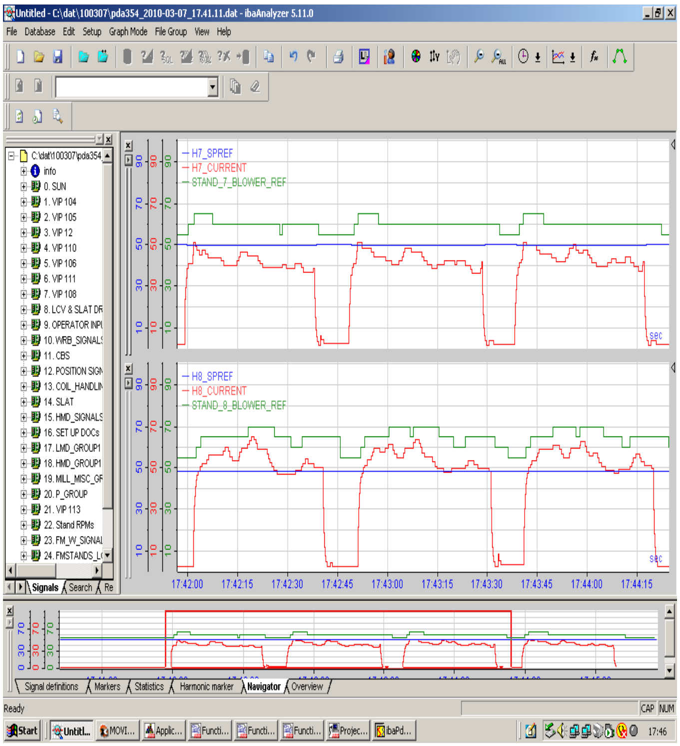

Fig. 4-

Actual Power saving data Table for size (5.5 mm)

Results summary in terms of Kw h and Rs. As compare to old system (Avg 15 stands in rolling)

B. Motor	Operating speed in %		Frequency in Hz		Power consumption in Kw	
	Present	Previous	Present	Previous	Present	Previous
Stand-1	70	100	35	50	4.5	11.3
Stand-2	70	100	35	50	4	11.6
Stand-3	70	100	35	50	4.5	11.3
Stand-4	60	100	30	50	2.8	11.3
Stand-5	60	100	30	50	2.7	11.4
Stand-6	60	100	30	50	2.8	11.4
Stand-7	60	100	30	50	2.6	11.4
Stand-8	60	100	30	50	2.6	11.5
Stand-9	60	100	30	50	2.9	11.4
Stand-10	60	100	30	50	2.8	11.5
Stand-11	60	100	30	50	2.9	11.4
Stand-12	60	100	30	50	2.7	11.3
Stand-13	60	100	30	50	2.7	11.6
Stand-14	60	100	30	50	2.8	11.6
Stand-15	64	100	32	50	3.4	11.3
Stand-16	70	100	35	50	4.2	11.3
Stand-17	64	100	32	50	3.6	11.3
Stand-18	60	100	30	50	2.7	11.4
Average power consumption					3.7	11.3
Percentage power saving					67.26	

System	Modified (Project)	Old (B Project work)
Month	02-10-2011	02-05-2011
Total time excluding maintenance shift	640	640
Total time when mill is on load in min	330.63	330.63
Delay with mill OFF in min	132.8	132.8
Delay with mill ON in min	176.57	176.57
Avg Power consumption when mill on load in Kw h	15374.29	56041.79
Avg Power consumption Mill OFF in Kw h	3187.2	22509.6
Avg Power consumption when Mill idle ON in Kw h	5179.2	29928.62
Total Power consumption in Kw h	23740.4	108480
Power saving in Kw h	84739.6	
Money Saved in Rs	4,23,698	

Discussion

The reference generation with the project scheme was satisfactory and the motor temperature of the main motor was in limit. Further tuning of the reference can save more power. It was required to study in detail the exact rate of cooling requirement based on the load and mill condition. The use of temperature sensor's may help in further reducing the power consumption. The expected saving nearly 10 %.

Conclusion

This Paper has reviewed the growth of efficient energy utilization in the steel rolling mill for main stand motor cooling arrangement & described methods for speed management dynamically based on the rolling load on the motor automatically. Implementation of this scheme will save around 40 – 60% power as compare to the conventional system. This scheme can be implemented to all the rolling mills in India and internationally. After study the start up sequence, loading and unloading of the Main stand Motors.

Expected Energy saving with the proposed scheme is 50,000 to 60,000 Units per month for M/S Sunflag Iron and Steel company . In terms of Rupees around 2,50,000 to 3,00,000 per month.

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