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AC Motor cooling system Analysis Based on Application Case Study

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Abstract: *It is always good to study the actual application to improve the performance of the motor. New analytical method for cooling and ventilation of induction motor to provide precise result in a short period. Now a day AC motor taken the place of DC motors even in variable speed requirement, In any plant AC motor are widely used from small to bigger . The cooling system of unregulated self ventilated motor operating in the heat area can be severely deteriorated by the dust and heat in the steel plant .As a result, these motors can become overheated even with operation current below the rated current. The cooling system of regulated motor with self or externally ventilated area can be severely deteriorated at lower speed in the steel plant. As a result, these motors can become overheated even with operation current below the rated current. Energy consumption by the air blower plays a vital role in optimizing the energy consumption. This article indicates that the loading pattern of the AC motor and speed should decide the control strategy for effective and efficient cooling arrangement.*
Keywords: *Energy efficiency, Load Analysis, Mill operating condition, Rated Current, Regulated motor, unregulated motors.*

I. INTRODUCTION

Compact and light weight induction motors are more and more needed in recent years. The significance in cooling motors by ventilation has been increasing accordingly. In the typical steel plant driven by electrical systems, AC motors are used for rolling stands, conveyors and Roller tables, Lubrication, Hydraulic, combustion blowers etc. Generally the motors for roller table, hydraulic, lubrication are fixed speed motors are small in size. Hence, self cooling is sufficient for these motors. Conveyor motors are regulated motors and ventilated with the external air cooling arrangement. Rolling stand motors are bigger in size, and hence the heat generation is more. This forces the use of separate air circulation system for each motor which circulate air for cooling to each of these motors. The amount of water circulation, speed of cooling blower motor, and rating fixed at the time of motor design by the motor- manufacturers are the vital parameters for redesigning the system for operation at higher energy-efficiency. The cooler unit should be able to adequately cool the AC machine so that it can be operated up to full load to further include the overload or service factor margin. Maximum heat generation is considered at this stage and accordingly blower motor capacity is chosen.

In all the steel rolling mills, the blower motors are operated at rated speed and consuming 100% of its rated power, even though heat generation by the main motor less. Hence it is mandatory to study the motor loading patter n to operate the blower motor under optimum conditions.

Motor cooling system has been studied extensively during the past decades, which describe many techniques for analysis of winding failure, temperature measurement, winding resistance measurement, consideration for cooling methods [1]. This article describes the AC motor cooling considerations for the steel industry. Analyses of external and self cooling systems are done for the effect of chemicals present in cooling air on motor components.

II. DATA COLLECTION BASED ON TYPES OF MOTOR

2.1. Unregulated Motor

2.1.1. Unregulated Combustion Blower Motor with shaft mounted fan cooling arrangement:- Type 1LA2245-4 Frame 355S, 160 kW , RPM-1485, Volts-415, Amp-265, Insulation-F, Duty-S1, C Frequency – 50 Hz, Make ABB

Fig. 1. Unregulated motor with shaft mounted fan cooling arrangement.

2.1.2. Unregulated Roller table Motors with self cooling arrangement:- Type 1LA2245-4 Frame 225M/4 TF OL-H, 30 kW , RPM-1470, Volts-415, Amp-52, Insulation-F, Duty-S1, C Frequency – 50 Hz, Make ABB

Fig. 2. Unregulated motor self cooling arrangement

2.1.3. Unregulated Rolling Stand motor with shaft mounted fan cooling arrangement (AC Slip ring) Make- CG, Frame-520L, 932 kW , RPM-737, Volts-415, Amp-1625, Insulation-F, Duty-S1, Phase-3 Frequency – 50 Hz, RV-1050, RA-530

Fig. 3. 937 kW Unregulated motor with shaft mounted fan cooling arrangement.

2.2. Regulated Motors

2.2.1. Regulated Conveyor Motors with external cooling fan:-: Type : AC-SQC, 11 kW , RPM-1470, Volts-415 Amp-20.5, Insulation-F, Duty-S4, Frame-160M, Phase-3 Frequency – 50 Hz, Make BBL, Blower Motor-kW-.12, RPM 1310, Amp- .60, Duty- S1, Insulation- F, Make BBL

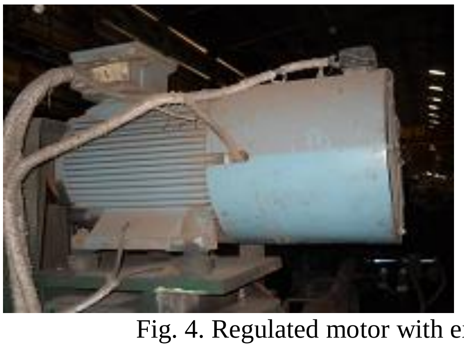


Fig. 4. Regulated motor with external fan cooling arrangement.

2.2.2. Regulated Roller Table Motor with shaft mounted fan:- Type : AC-SQC, 1.7 kW , RPM-1900, Volts-415 Amp-4, Insulation-F, Duty-S1, Frame-112M, Phase-3 Frequency – 50 Hz, Make BBL, Fig. 5.

Fig. 5. Regulated motor with fan on shaft for cooling

2.2.3. Regulated Rolling Stand Motor with external cooling arrangement
Type : AMI 630L, 1250 kW , RPM-230-430-650, Volts-426-690-690, Amp-2067-1369-1215, Insulation-F, Duty-S9, Connection – Delta, Phase-3 Frequency – 13.2- 21.6- 32.7 Hz, Make ABB, Blower Motor- kW-15, RPM 1470, Amp- 27.7, Duty- S1, Insulation- F, Make ABB

Fig. 6. Regulated AC squirrel cage motor with external cooling arrangement.

Heat Exchanger
Heat dissipation of cooler : 160 KW, Air flow:- 2.2m^3/Sec
Air temp. Inlet to cooler: 78.83 deg, Air temp. outlet from cooler 50 deg Cooling water flow: 130 LPM C.W. inlet temp. from cooler : 35 deg, CW outlet temp. from cooler: 42.47 deg Air Pressure drop: Across cooler : 2.4 mm W.G., Water pressure drop: 7.4' of water coll um, Yd. test pressure 10 Kg/cm^2

III. AC MOTOR COOLING SYSTEM

The cooling system for the AC induction motors consider for stator and rotor. AC motor can be ventilated from driving or non driving end. Unregulated motors cant be self ventilated or by providing emperor on the shaft.Bigger size motor can be externally ventilated. While small regulated motors ventilated externally by providing air blower and bigger motors are cooled with circulating air along with water heat exchanger. In this design, circulating air is cooled by the water passing through heat exchanger. AC slip ring motors have many brushes which produce carbon dust. It is better to blow out the carbon dust from the slip ring to reduce tracking when mixed with humid air and other contaminations hence separate blower used for slip ring.

In the steel rolling mill, load on the rolling stand motors, conveyor motors. Roller table motors not fixed and this is the main cause of variable heat generation in the motor. Cooling Blowers are operated at rated RPM and consume rated power. The load on the motor is varying as per the section requirement. Cooling system is, however, not optimized accordingly.

This poses an interesting question for the motor with a variable load. Measuring motor temperature under the variable load and deciding the suitable blower-motor-speed and the required rate of cooling-water-flow are then required. Temperature of the motor for different load conditions and the corresponding blower motor speed are the criteria for designing the control philosophy to optimize the input to the cooling system.

IV. RECORDING OF THE LOAD, SPEED, TEMPERATURE OF AC MOTORS

Unregulated and Regulated motor RPM, load, Temperature and Shaft mounted fan RPM recorded in the Table1, 2, 3, 4 and 5 for the different operating condition and applications. The analysis of this data is very useful to design a control system to optimize the power consumption of the fan and blower motors used for the cooling of AC motors.

Table 1. Unregulated Motor with shaft mounted fan.

Sr. No.	Motor actual current	Motor RPM	RPM in % (100% =1485 RPM)	Fan RPM speed in %	Current in % 100% = 265 A	Temperature in Deg C
1	165	1485	100	100	62.26	60
2	190	1485	100	100	71.7	62
3	210	1485	100	100	79.25	65
4	220	1485	100	100	83.02	65
5	230	1485	100	100	86.79	69
6	240	1485	100	100	90.57	70

Table 2. Regulated Roller Table Motors with shaft mounted fan.

Sr. No.	Motor actual current	Motor RPM	Speed in % (100% =1900 RPM)	Fan speed in %	Current in % 100% = 4 A	Temperature in Deg C
1	3.2	475	25	25	80	85
2	3.2	995	52.37	52.37	80	80
3	3.2	1105	58.16	58.16	80	69
4	3.2	1300	68.42	68.42	80	65
5	3.2	1550	81.58	81.58	80	65
6	3.2	1900	100	100	80	62

Table 3. Regulated Conveyor Motor with Shaft mounted fan only.

Sr. No.	Motor actual current	Motor RPM	Speed in % (100% =1900 RPM)	Fan speed in %	Current in % 100% = 20.5 A	Temperature in Deg C
1	19.5	394	20.74	20.74	95.12	85
2	19.5	479	25.21	25.21	95.12	82
3	19.5	481	25.32	25.32	95.12	82
4	19.5	825	43.42	43.42	95.12	75
5	19.5	1033	54.37	54.37	95.12	70
6	19.5	1300	68.42	90	95.12	65
7	19.5	1500	78.95	80	95.12	62
8	19.5	1900	100	0	95.12	60

Table 4. Regulated Conveyor Motor with shaft mounted fan and external fan.

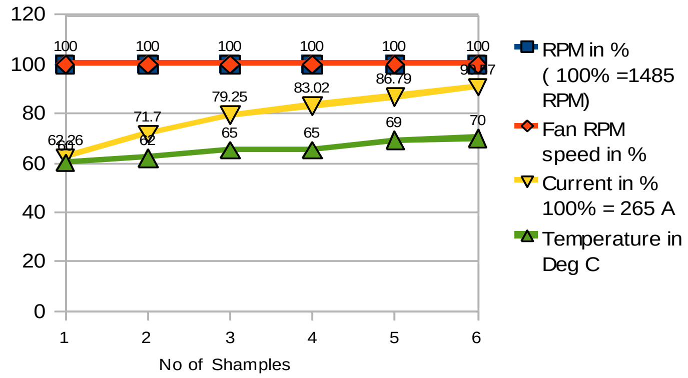
Sr. No.	Motor actual current	Motor RPM	Motor RPM in % (100% =1900 RPM)	Fan RPM in %	Current in % 100% = 20.5 A	Temperature in Deg C
1	19.5	394	20.74	100	95.12	57
2	19.5	479	25.21	100	95.12	56
3	19.5	600	31.58	100	95.12	57
4	19.5	825	43.42	100	95.12	50
5	19.5	1033	54.37	90	95.12	60
6	19.5	1300	68.42	90	95.12	60
7	19.5	1500	78.95	80	95.12	60
8	19.5	1900	100	0	95.12	60

Table 5. Regulated Rolling Stand Motor with external cooling system.

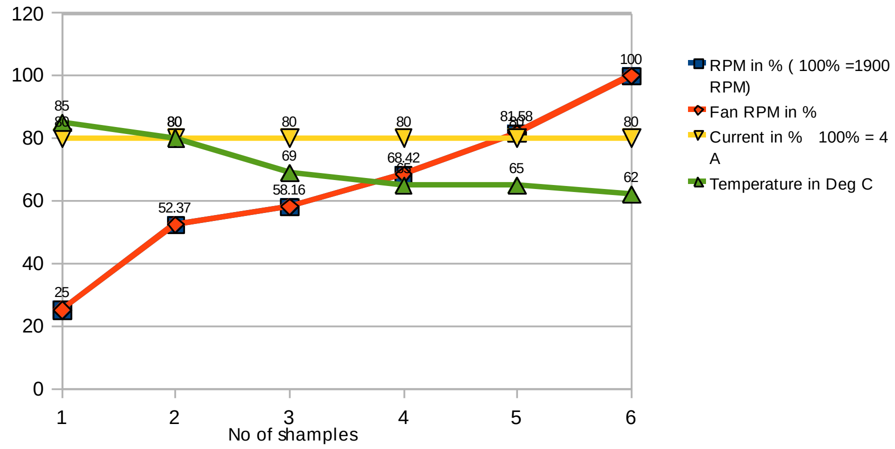
Sr. No.	Motor actual current	Motor RPM	Motor RPM in % (100% =650 RPM)	Blower RPM in %	Current in % 100% = 2067 A	Temperature in Deg C
1	1900	394	60.62	100	91.92	57
2	1800	479	73.69	100	87.08	56
3	2300	600	92.31	100	111.27	57
4	1500	250	38.46	100	72.57	50
5	2000	300	46.15	90	96.76	60
6	1700	400	61.54	90	82.24	60

V. ANALYSIS

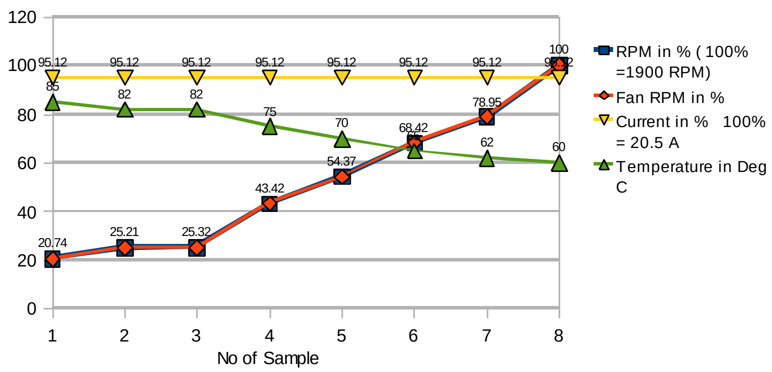
Data analysis is done to optimize the cooling system for power saving. Application wise analysis is done for the Motor RPM and Temperature. Temperature of the motor compare by keeping load on the motor constant for regulated and unregulated motor. The effect of Motor RPM on the temperature compared for the different cooling arrangement. Based on this analysis, it is easy to develop a control system for operating the cooling blower in such a way to save the power. In this paper only the sample graphs are presented for the analysis. Graph 1 shows the analysis of RPM and Temperature of unregulated shaft mounted fan motor. Graph 2 shows the analysis of RPM and Temperature of regulated Roller Table motor with shaft mounted fan. Graph 3 shows the analysis of RPM and Temperature of regulated conveyor motor with shaft mounted fan. Graph 4 shows the analysis of RPM and Temperature of regulated conveyor motor with external fan. Graph 5 shows the analysis of regulated rolling stand motor with external cooling system.



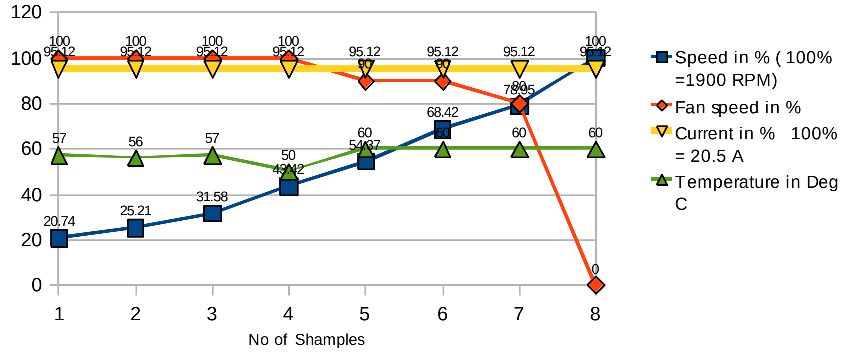
Graph 1. Unregulated Motor effect of load on Temperature



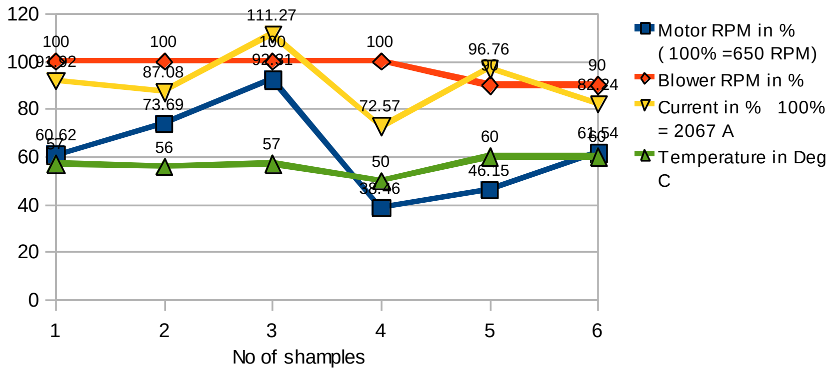
Graph 2. Regulated Motor: Effect of RPM on Motor Temprature keeping load constant with shaft mounted Fan



Graph 3. Regulated Motor: Effect of RPM on Temprature keeping load constant for shaft maunted fan



Graph 4. Regulated Motor: Effect of Motor RPM on Temprature with shaft mounted and external cooling fan keeping load constant.



Graph 5. Regulated motor: effect of load and RPM on Temperature with external cooling system.

VI. DISPOSITION OF CARBON DUST ON SLIPRING

Large number of papers have been written on dust disposition on the slip ring. Careful attention is made to the design of air pressure control to reduce dust affecting slip ring. Adequate air press will not allow the carbon dust to deposit on the slip ring.

The primary source of this dust is the wear and tear of the brushes due to friction. This can be blow out by providing gap at the slip ring encloser.

VII. RESULTS AND DISCUSSION

7.1 Results

Data analysis shows that the Roller table motor operates at high speed hence the self cooling arrangement is sufficient, But for the conveyor motor operation at low speed is required hence the external cooling system required at the higher speed shaft mounted fan sufficient for cooling. Regulated motor used for rolling stands are operated at 40 to 125 % load for very short period, hence the temperature rise is very less.

7.2 Discussion

The load analysis study will help to develop the generalized control system to save the power utilized for cooling the main motors in the steel rolling mills. This study will help for how to improve the motor efficiency to fulfill the requirement of additional load whenever required. To achieve this 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.

VIII. CONCLUSION

This paper has provided the analysis of the AC motor temperature, load and cooling system in steel rolling mill to design the optimize cooling system for AC Motors to save the auxiliary energy consumption.

Following conclusion are drawn from the analysis of the AC Motor temperature, Load and Cooling system used for the AC Motors in steel rolling mill considering the different factors.

1. Use of cooling system depends on the application of the motor.
2. Unregulated motor generally with the shaft mounted fan ventilation system, Hence the frame size of the motor bigger than the motor use with external ventilation system.
3. Unregulated motor generally with the self ventilation system, Hence the frame size of the motor bigger than the motor use with external ventilation system.
4. Regulated motors are with external fan cooling system. This arrangement good at the lower speed, at the higher speed it is observed that energy consumption is more due to external fan. This can be optimize by providing shaft mounted fan with external fan. Hence at the higher speed external fan can be switched OFF.
5. Regulated motor for the Roller table with shaft fan cooling arrangement are not in continuous operation hence the cooling is sufficient.
6. Type of external ventilation system depends on the size of the motor. For small size external cooling fan is used for cooling. And for the bigger motor heat exchanger used for the cooling.
7. Unregulated AC slip ring motor generally with the shaft mounted fan ventilation system, Hence the frame size of the motor bigger than the motor use with external ventilation system. Separate cooling arrangement used for the slip ring.
8. Load on the rolling stand not continuous in the steel rolling mill. This leads to the conclusion that as the motor is running at lower load, it generates less heat. This data can be utilized to develop a control philosophy to save the blower motor power during this period. It also lead to the conclusion that off load period of the motors can be utilized for power saving by developing the control philosophy. Expected power saving by developing the control philosophy using the data can save 15 % of power required for cooling blowers.

REFERENCES

[1] JSME, “Data Handbook of Heat Transfer Engineering,” JSME1971

[2] Siward Cheng, I Du, Jose A. Restrepo, Pinjia Zhang and Thomas G. Habetler, “Power Electronics” IEEE Trans. On volume: PP, Issue: 99 2012,Page(S) 1-1

[3] Walter J and Konstanty, “ DC Motor Cooling Considerations” (PPIC) 2011, page(s): 159 – 162

[4] Paul Buckley, H. Hawkeye King, Marta Wang and Blake Hannaford, (WHC) IEEE 2011, page(s): 143 – 148

[5] M. Aniblal Valenzuela and Guillermo Ramirez, “Industrial Application” IEEE trans. Volume:47, Issue:2, 2011, page(s) 719 – 729

[6] Ye Zhen-nan, Luo Wei-dong, Zhang Wen-ming and Feng Zhi-xiang, “Electric Information and Control Engineering” 2011, Page(s): 746 – 749

[7] Boglietti, A. Cavagnino, A. Staton, D.A. Popescu, “Power Applications” IET, 2011, 5 (2), 203 – 209.