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"Comparison of different Cooling system used for DC Motor" Case Study

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Abstract:- The need of cooling arrangement for DC motor is very important to reduce the frame size of the motor. It required to select the effective cooling arrangement of the DC motor based on the application, surrounding of the motor installation and power consumption. DC motors are the workhouse variable speed drives in the continuous steel rolling mills for many years. DC motors in the steel rolling mills are usually separately ventilated. The quantity and quality of the cooling air can have major impact on the DC motor performance, operation, maintenance and life between overhauls. Energy consumption in the cooling system depend on which type of cooling used and what is the nature of load in that application. The air blower plays a vital role in optimizing the energy consumption. This article indicates that the how different type of cooling arrangement makes difference on the performance of DC motor, Maintenance and life of the DC motor and provide the information for selecting the better cooling system.

Keywords:- Cooling system, Energy efficiency, Surrounding , Load, Application.

I. INTRODUCTION

In any continuous steel rolling mill driven be electrical systems, DC motors are used for rolling stands, cropping and chopping shears, pinch roles and cooling bed , block and garret applications. Generally the auxiliary motors used as a supporting equipment are small in nature. Main motors used for Rolling stand are bigger in size.

This case study applicable to M/S Sunflag Iron and Steel company, Bhandara. Where auxiliary motors used for Pinch rolls, Cooling Bed, Decelerator and shuffle bar are of the small capacity and and the motor used for main stands from 1 to 20 are bigger capacity. Inter stand shear are having the middle capacity. For the auxiliary motor forced cooling system used, for the main stands motor forced air with circulating water and for some motor only forced air cooling is used and for inter stand shear both air and water cooled system used.

In all the auxiliaries, Main stands and inter stand shears 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 different motor cooling system to operate the blower motor under optimum conditions to save the power and improve the maintenance frequency.

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 [2]. This article describes the DC motor cooling considerations for the paper industry. Analyses of external and self cooling systems are done for the effect of chemicals present in cooling air on motor components.

II. METHODS OF COOLING

Method of cooling is defined by NEMA with descriptive phrases, i.e., "Non-ventilated" - no cooling by means external to the enclosure. IEC designates method of cooling by letter "IC" (index of cooling) followed by two digits with the first digit giving the cooling arrangement and the second digit indicating the method of power to circulate the coolant. For example, "IC 40" - "4" - frame surface (exterior) cooling. "O" - free convection. In NEMA designation this would be NV. Although the terminology for both motor enclosures and method of cooling varies with NEMA and IEC, a correspondence between the two terminologies can be obtained for specific application conditions. Large number of papers have been written on dust disposition on the commutator. Careful attention is made to the design of air pressure control to reduce dust affecting commutator. Adequate air press will not allow the carbon dust to deposit on the commutator. The primary source of this dust is the wear and tear of the brushes due to friction. This can be blow out and filter by the filter before entering to the heat exchanger.

III. ENCLOSURES

The selection of the proper enclosure is vital to the successful safe operation of DC motors and generators. The wrong enclosure can pose hazards to operating personnel and endanger other equipment. In addition, machine performance and life can be materially reduced by using an enclosure inappropriate for the application. The customer must recognize the specific environmental conditions and specify the correct enclosure. Reliance Electric can provide application assistance but must depend on the customer to provide accurate information on the operating conditions. The information in this section, the General Information Section and the Modification Section should be studied thoroughly before specifying an enclosure. As indicated in the General Information Section, the basic DC motor may be Drip-proof Guarded, Drip-proof Guarded Force Ventilated or Drip-proof Guarded Separately Ventilated depending on horsepower rating. In addition, totally enclosed motors can be supplied when required by the application. The minimum enclosure for Reliance Electric DC motors is Drip-proof Guarded (DPG) as defined by NEMA MG1-1.25.5 to prevent accidental exposure to live metal or rotating parts. The drip-proof construction permits successful operation when drops of liquid or solid particles strike or enter the enclosure at any angle from 0 to 15 degrees downward from the vertical. Certain applications may require a Splash proof Guarded (SPG) machine to permit successful operation when drops of liquid or solid particles strike or enter the enclosure at any angle not greater than 100 degrees downward from the vertical. Both Drip-proof Guarded and Splash proof Guarded machines may have a blower driven by a constant speed AC motor mounted on the end bracket to provide cooling independent of DC motor speed. See M-329 (Speed Range by Armature Voltage Control). A filter may be added to the blower when filterable contaminants are present in amounts not sufficient to rapidly clog the filter. A filter is not recommended in extremely dusty, dirty locations. For dusty, dirty environments, a totally enclosed machine is required to prevent the free exchange of air between the inside and outside of the enclosure but not sufficiently enclosed to be termed air-tight. The following totally enclosed machines are available and may be priced from either the Pricing Section or the Modification Section.

Totally Enclosed Non-Ventilated - Not equipped for cooling by means external to the enclosing parts. Generally limited to low horsepower ratings or short-time rated machines.

Totally Enclosed Fan Cooled - Exterior surface cooled by external fan on motor shaft. Available in ratings Motor cooling is dependent on motor speed.

Totally Enclosed Air-Over In-line - External fan driven by constant speed AC motor flange mounted to motor fan shroud. Provides cooling independent of motor speeds. Brakes and tachometers cannot be mounted on motor end bracket except for specific small tachometers which can be nested between motor bracket and fan. Available thru C400ATZ frames.

Totally Enclosed Air-Over Piggyback - Has top mounted AC motor driven blower shroud to direct ventilating air over motor frame. Available thru C400ATZ frame.

Totally Enclosed Dual-Cooled with Air-to-Air Heat Exchanger (TEDC-A/A) - Cooled by circulating motor internal air through the heat exchanger by an AC motor driven blower. External air circulated through the heat exchanger by another AC motor driven blower removes heat from the circulating internal air. No free exchange of air occurs between the inside and outside of the motor.

Totally Enclosed Dual-Cooled with Air-to-Water Heat Exchanger (TEDC-A/W) - Similar to TEDC A/A except external circulating air flow is replaced by customer supplied water to remove heat from heat exchanger. Available in ratings through 3000 HP.

T**otally Enclosed Pipe-Ventilated (TEPV) or Totally Enclosed** Separately-Ventilated (TESV) - Motor is cooled by customer supplied air which is piped into the machine and ducted out of the machine by customer supplied ducts.

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The entire document should be in Times New Roman or Times font. Type 3 fonts must not be used. Other font types may be used if needed for special purposes.
Recommended font sizes are shown in Table 1.

IV. DIFFERENT TYPE OF COOLING SYSTEM USED FOR DC MOTOR

Cooling air through a self-ventilated or forced-ventilated motor must be clean and have relative humidity between 30% and 100% with no free water in the air. Use of damp, cool outside air with high humidity and free water may cause the motor to flash over. Use of excessively dry air may cause excessive brush and commutator wear. Cooling air temperature must not exceed the maximum ambient temperature indicated on the motor nameplate (Standard 40 Deg C). Cooling air temperature must not be lower than 0 Deg C to provide base speed and regulation within NEMA limits. Use of outside air below 0-C may cause excessive brush and commutator wear due to the low humidity. Cooling air absolute humidity must be at least 2 grains per cu. ft. DC motor can be ventilated from commutator or non commutator end. Smaller motors are ventilated by air cooled system only, While large 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.

A. **Air Blowers on the Top and side (CA)- In this arrangement side motor is forcing the air in motor while the top motor extracting the air from the motor.**

Fig 1 – cooling system of 75 kW DC motor. (Circulating Air)

B. ***Air Blowers on the Top (FA)*** *- In this arrangement Blower is forcing the air in motor and this air coming out from the ventilation grills.*

Fig 2 – cooling system of 75 kW DC motor. Forced air cooling

C. **Air Blowers on the Top with ventilation grills at NDE (FA) -** In this arrangement Blower is forcing the air in motor and this air coming out from the ventilation grills.

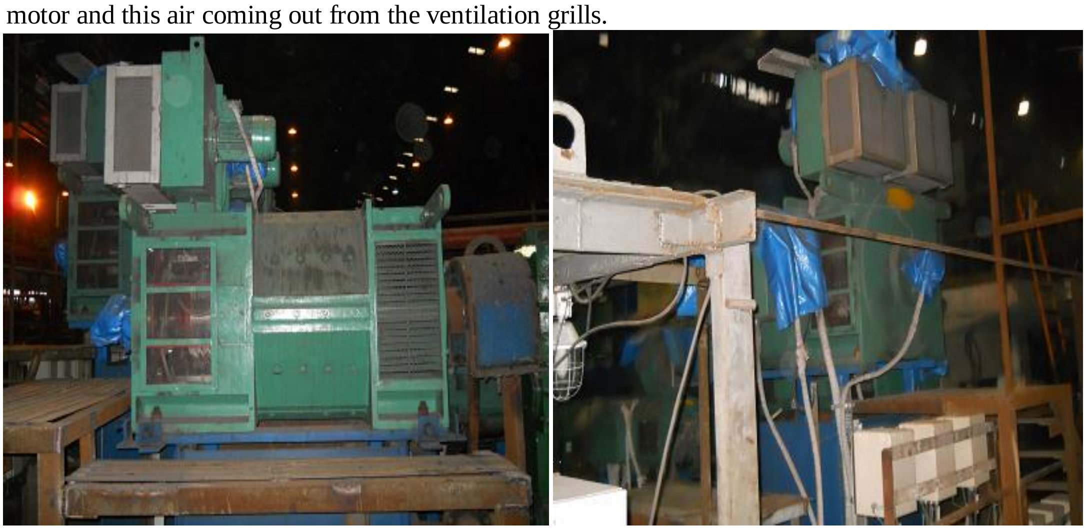

Fig 3 – cooling system of 600 kW DC motor. Forced air cooling

D. **Circulating air Circulating water (CACW) –** In this arrangement air blower used to circulate the air in the motor and heat exchanger. Water circulate through the heat exchanger and cool the hot air. In this system no external air added hence the contamination of air not occurred. Only the carbon dust disposition is there in the motor.

Fig 4 – cooling system of 600 kW DC motor.(with circulating water without inlet and outlet vent.)

E. **Circulating air Circulating water with vent grills at non driving end (FA CACW) -** In this arrangement air blower used to circulate the air in the motor and heat exchanger. Water circulate through the heat exchanger and cool the hot air. In this system air vent from the vent at non driving end and enter in the motor from the filter at the NDE. Hence the contamination of air takes place. In this system blower are taking more current hence consuming more power. Large motors have many brushes which produce carbon dust. It is better to blow out the carbon dust from the motor to reduce tracking when mixed with humid air and other contaminations.

Fig 5 – cooling system of 600 kW DC motor.(with circulating water with inlet and outlet vent.)

V. COMPARISION

Considerations:
Comparison based on the same working condition.
Comparison based on the same surrounding condition
Comparison done for the motor of equal rating.

Comparison of cooling system done on the basis of power consumption, surface temperature of the motor, Capital Cost , Maintenance cost, Defects due to cooling system and possibility to use by keeping RPM of the blower motors constant at the equal main motor load.

TABLE 1- COMPARISON OF DIFFERENT DC MOTOR COOLING (CASE STUDY)

Sr. No.	Description	Type of Cooling System			
		CA	FA	FACACW	CACW
1	Power Consumption	Moderate	More	Moderate	Less
2	Surface Temperature of Main Motor	More	Moderate	Less	Less
3	Capital Cost	Less	Moderate	More	More
4	Maintenance cost	Less	More	Moderate	Less
5	Possibility of Main Motor Failure due to Wet air	No	Yes	Yes	No
6	Maintenance Frequency	Less	More	Moderate	Less
7	Carbon deposition on commutator and Motor	More	Less	Moderate	More
8	Pigtail of Carbon brush Breaking	Less	More	Moderate	Less
9	Commutator oxidation	No	Yes	Yes	No
10	Possibility to use in dusty area	Yes	Not Recommended	Not recommended	Yes
11	Possibility to use in wet area	Yes	Not Recommended	Can be used	Yes

VI. EXPERIMENTAL RESULTS

Experimental results shows that circulating air circulating water cooling arrangement is better that all the cooling arrangement used for M/S Sunflag steel co. where the surrounding of motor is dusty and wet. This save the motor from failure due to wet dust and increase the maintenance span.

Fig 6 shows that the power consumption is more in the Total enclosed without circulation with ventilation and minimum power consumption in TE with water circulation cooling system. Temperature of the motor with TE with water circulation and ventilation minimum.

Fig 7 shows that the maintenance frequency of the Total enclosed without water circulation with ventilation high and minimum in TE with water circulation cooling system. Hence the man days required for the maintenance of TE without water circulation and ventilation more and minimum for the TE water circulation cooling system.

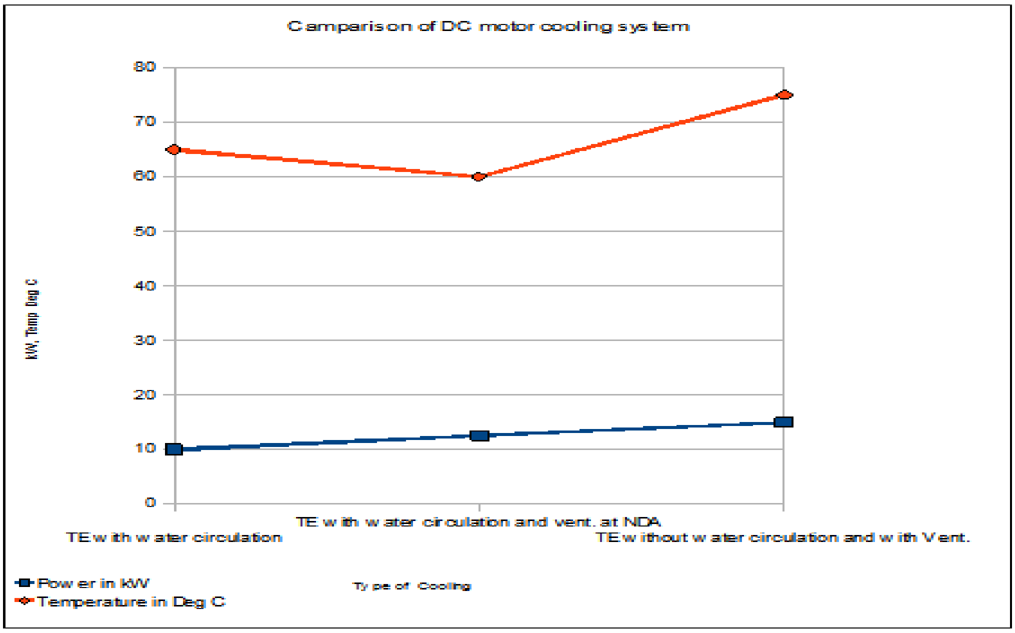

Fig 6 – Comparison of cooling system for power consumption and surface temperature of the motor.

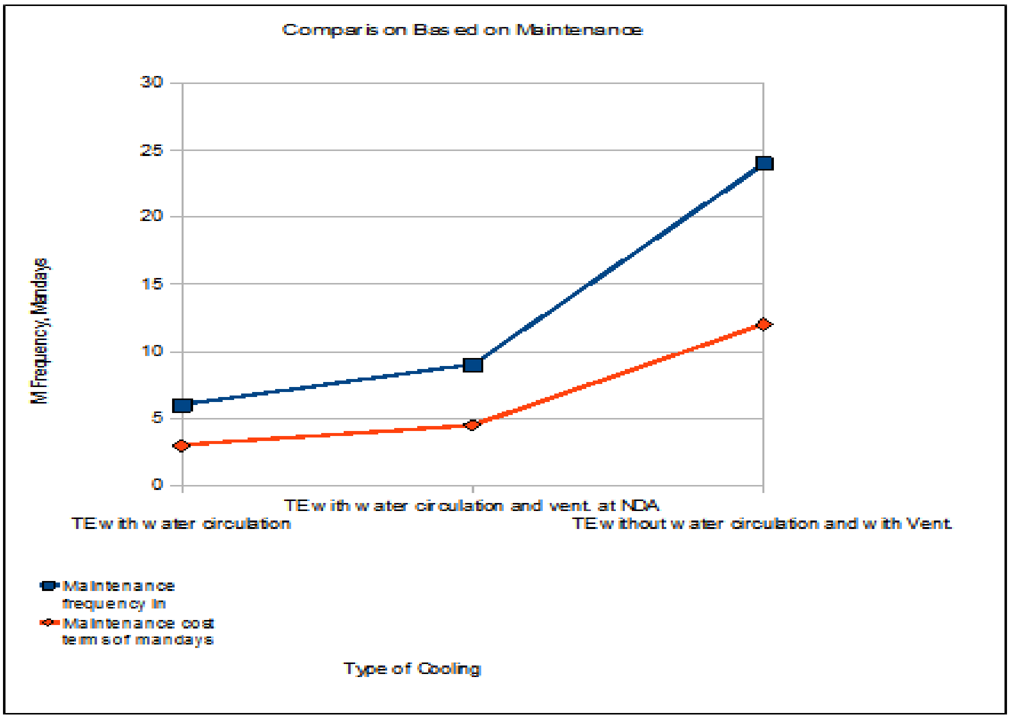

Fig 7 – Comparison of cooling system for power consumption and surface temperature of the motor.

VII. CONCLUSIONS

This paper has provided the analysis of the cooling system for DC Motors used in the steel rolling mills to fulfill the requirements of different application.

Following conclusion are drawn from the caparison of different cooling system used for DC Motor.
1. Circulating air circulating water cooling arrangement is better in all the surrounding condition. Power consumption of this system is less. Only the water and the initial cost is the problem with this system. But the surrounding area is dusty and wet it is recommended to use this type of cooling only even the initial cost is more. This will protect the motor from failure due to dust and increase the maintenance span.
2. Forced air with air inlet water cooled cooling arrangement is better where the surrounding air of the motor not wet. This will consume more power as compare to the case 1 but provide the better cooling effect. This system not useful for the application where the surrounding area is dusty and wet.
3. forced air cooling system consume more power and oxidation of commutator can takes place when used at wet condition. Capital cost of this cooling system is low as compare to any other system. This system can be effectively used where the ambient temperature low and surrounding area is dry.
This leads to the conclusion that even the capital cost of the circulating air circulating water cooling system is more it is better to use this system. It also lead to the conclusion that the initial cost can be compensated due to less maintenance and more span of equipment availability.

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