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Reduce the Effect of Higher Temperature on High Voltage Electrical Insulation

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ABSTRACT

In high voltage engineering mica based insulation mostly used. But such a insulation have good dielectric strength-have relatively poor thermal conductivity. It will affect the insulating strength and finally decrease the overall efficiency of high voltage insulation. By using specific filler reduce the effect of higher temperature on insulation system without changing design parameter.

Keywords: Turbo Generator, Heat Transfer & Analysis, Filler Characteristic, High Voltage Insulation System

I. INTRODUCTION

Direct cooling in turbo generator where hollow stator bar cooled by hydrogen gas or water. Generated heat in the conductor directly transmitted to coolant. While in indirect cooling heat produced by the conductor pass through the wall insulation to the coolant. Due to thermal barrier characteristic of mica, it will restricting the efficiency of the cooling system limiting capacity of generator. Insulating material used in higher speed and voltage rotating machine require higher thermal stability and higher thermal conductivity. If the thermal conductivity of the insulation higher , higher thermal gradient in the insulation will be reduced resulting in less thermal stress [2].Thermal conductivity of mica insulation is between .25 and .30 W/mK (Figure 1) [2].

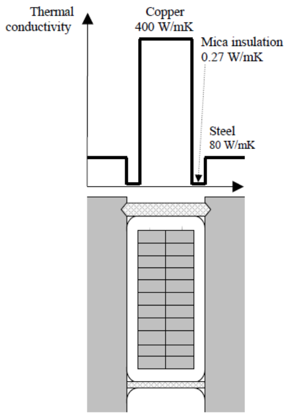


Figure 1. The mica insulation as a thermal barrier in a generator stator

Insulation material with higher thermal conductivity can transfer heat faster and minimize thermal stress on the insulating material. Heat transfer from the conductor to coolant by (1) Reduced main wall thickness (2) increased thermal conductivity of mica insulation & (3) higher heat resistant insulation. The second one –mica insulation with higher thermal conductivity generator performance improved without changing in coil design and insulation thickness.

Thermal calculation is to finding temperature rise in part of rotating machine which are in direct contact with the insulation. Temperature of active part increased with increasing the load that will increased the stress of electrical insulation.

The purpose of thermal calculation is to determine the medium and minimum temperature rise in individual part of electrical equipment which is in direct contact with the insulation of electric rotating machine [1]. To reduce the heat loss in ferromagnetic part of machine Reduce the bearing friction, air friction, and friction on brush. By using insulating material with high thermal conductivity ,thermal resistance decrease. It will reduce the size of machine and cost of electrical rotating machine. Material with value of thermal conductivity is given below table. All this material have higher breakdown strength but have a relatively low thermal conductivity.

Table I. Values of Thermal Conductivity [1]

Material	***λ*** **($W \cdot m^{-1} \cdot K^{-1}$)**
Copper	400
Steel	80
Epoxy resin	0.2
Glass	0.6 – 1
Mica	0,3 – 0,6
Aluminum oxide	25 – 40

II. METHODS AND MATERIAL

In HTC insulation system filler with high thermal conductivity added, but it is not easy to select proper filler material for mica insulation. Filler material to be used for reduce the temperature effect should have following characteristic[2].

- High thermal conductivity
- High electrical insulating capability
- High partial discharge resistance
- Compatibility with binder and impregnating resin
- Chemical stability and low toxicity
- Availability in consistent quality
- Practical cost

Generally two types of inorganic filler BN(hexagonal) and Al_2O_3 respectively 40-120 W/mK and 25-40 W/mK thermal conductivity. We can also use the glass and resin but it will disturb the mica plate orientation and also decrease the mechanical electrical properties where as little change in thermal conductivity.

Resin added with filler material in to the mica insulation, which is in either tape or part of the impregnating resin in the VPI (Vacuum Pressure Impregnating) process. The thermal conductivity of the main wall insulation change with respect to type and amount of filler added. Fig 2 shows BN(hexagonal) and Al_2O as a function of the volume fractional of filler material[2].

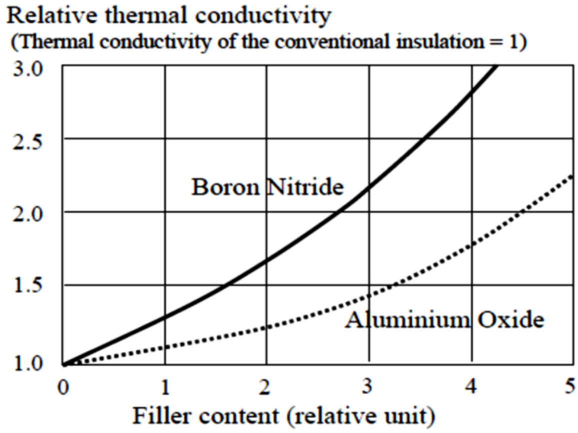
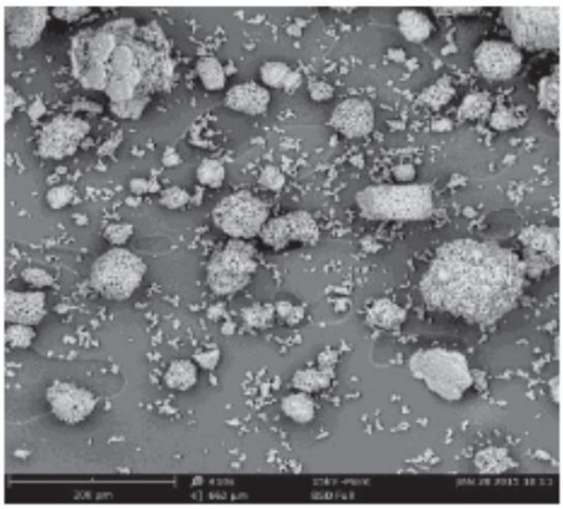


Figure 2. Thermal conductivity of insulation as a function of filler and content

Figure 2 shows that to get the target thermal conductivity of high voltage insulation less quantity of BN(hexagonal) require in compare to Al_2O_3 . Also shape of BN(hexagonal) has the platelets form while Al_2O_3 are in spherical form. So that BN(hexagonal) is most suitable and easier to apply filler but it more costlier than Al_2O_3 . to depend on the type An easy way to comply with the conference paper formatting requirements is to use this document as a template and simply type your text into it. By performing impregnation test with mica containing BN filler prove that the most suitable filler .

Due to higher cost sometimes Al_2O_3 also used . Value of thermal conductivity dependent on the dimensions and structure of the filler . The dimension of the Al_2O_3 was measured by electron microscope Phenom ProX shown in Fig.3[1].



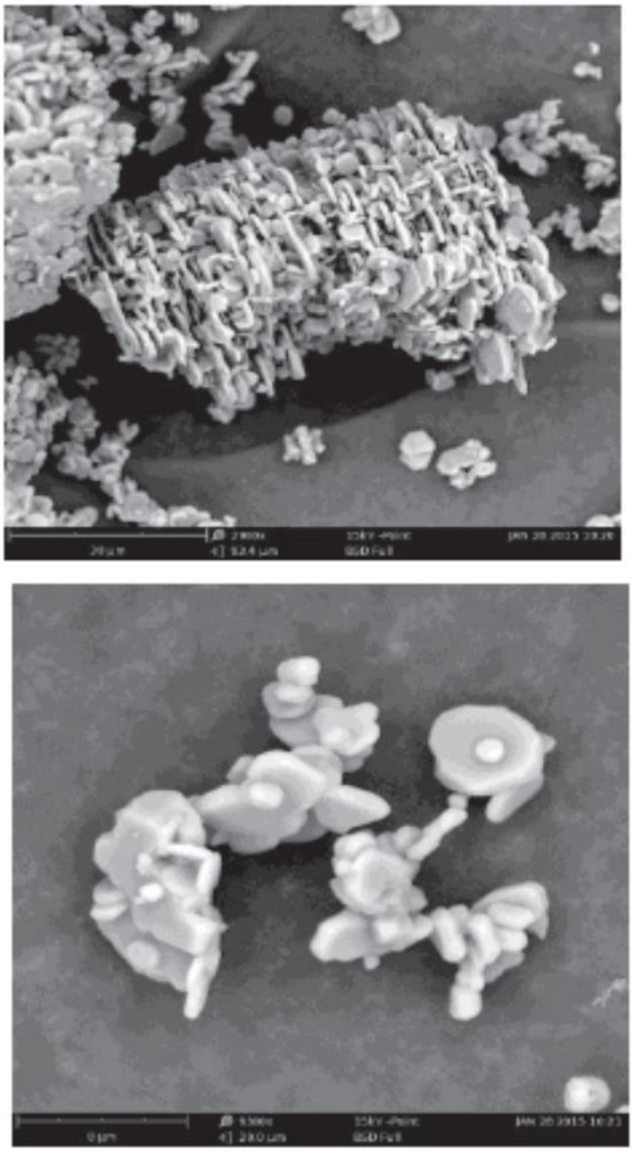


Figure 3. The filler particles(AL_2O_3)

Heat dissipation factor tanδ change with increase the thermal conductivity with the use of epoxy resin and. Thermal conductivity increase with higher amount Al_2O_3(2%,4%,6%,8% and 10%) [1].Table II show the value of thermal conductivity and.

The sample	λ ($W \cdot m^{-1} \cdot K^{-1}$)	tan δ
Pure Epoxy	0,22	0,0023
Epoxy + Al203 2 %	0,22	0,0022
Epoxy + Al203 4 %	0,23	0,0021
Epoxy + Al203 6 %	0,24	0,0028
Epoxy + Al203 8 %	0,28	0,0025
Epoxy + Al203 10 %	0,29	0,0027

Value of tanδ depending on the value of frequency. Hysteresis loss and eddy current loss depending on the value of frequency. Due to this losses heat will be generated which affect the heat dissipation factor. Fig 4 shows relation between frequency and tanδ filled by Al_2O_3 [1]

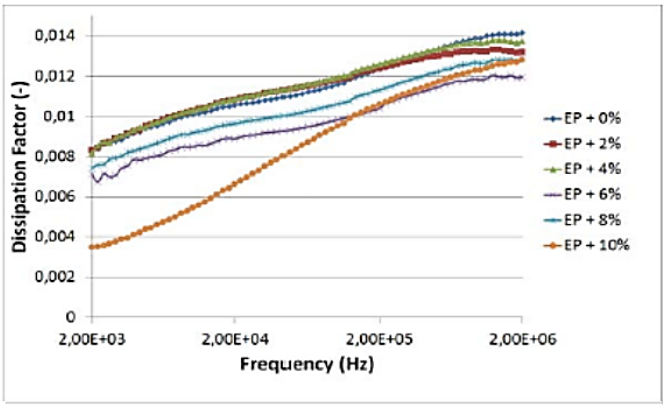


Figure 4. Relation between frequency and tanδ

III. RESULTS AND DISCUSSION

To reduce the effect of the of higher temperature improve the heat dissipation and thermal conductivity by using filler like BN(hexagonal) and Al_2O_3 without changing the design parameter which improve the reliability of high voltage rotating machine. If high thermal conductivity insulation is used overall efficiency of rotating machine increased without changing the original design.

The importance of filler increased mainly due to their mechanical ,thermal and electrical characteristic. Stator coil temperature reduced by using HTC insulation system. Efficiency of cooling system is improve to extend the range of indirect hydrogen gas and air cooled high voltage rotating machine.

IV. CONCLUSION

Thermal conductivity increases by adding the filler BN(hexagonal) and Al_2O_3 with mica and epoxy resin without change in dielectric strength of high voltage insulation. It also improve the life of insulating system which is become poor due to high temperature. Hence we reduce the effect of higher temperature on high voltage electrical insulation.

V. REFERENCES

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