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Monitoring of Sag & Temperature in the Electrical Power Transmission lines

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Abstract: For proper transmission of power in overhead transmission lines temperature control and sag monitoring are the two major parameters to be kept in mind. Electrical load variation and environmental changes affect the temperature in the transmission lines. For proper safety measurements these monitoring should be done on a continuous basis. Some of the ongoing temperature and sag monitoring methods that can be sited are the usage of stainless steel temperature probes, glass based sensors, thermocouples, RTDs, and Infrared sensors. However, all these methods have a disadvantage of having loosening of contacts. Cross sensitivity may also arise due to environmental contaminations. The disturbances caused by the different parameters can be stated as follows:- High temperature due to climate changes decreases the efficiency of electrical transmissions. Extreme weather conditions would increase the chances of failure rate of power lines. Temperature rise also results in an increase in thunder storms and results in the lightning strike of power lines. 2 degrees Celsius of temperature rise increases network losses by 0.04%. It is also found that operation of the conductors on high temperature reduces the mechanical integrity of the overhead systems. It is also clear that cumulative damage occurs to the Aluminium metal in the overhead conductors. Hence, in order to overcome these disadvantages, we hypothise the introduction of MEMS (Micro Electro Mechanical Systems) technology through PLZT(L. This is a temperature sensor, which has numerous advantages over the existing ones. The thin film of Lead Lanthanum zirconate titanate (PLZT) will be coated on nickel foil by chemical solution deposition and this will be fabricated as sensor using MEMS technology. The sensor in turn will be embedded in the transmission line at selected point wherefrom monitoring of temperature and sag is quite feasible. This sensor will be having high chemical stability , high mechanical and thermal resistances , good piezoelectric coefficients and enhanced sensitivity for which it will be reckoned to be a more accurate and versatile one.

Index Terms: MEMS, PLZT, sag, temperature control

I. INTRODUCTION

Transmission power lines are electrical lines that carry high voltage, e.g., 230 KV. For reasons of safety, such lines are suspended well above ground level. Power lines, which are generally supported by transmission towers, cover large distances. Due to the force of gravity, power lines intrinsically tend to sag. This initial sag increases with line temperature because the conducting material of which the line is made expands as line temperature increases, effectively lengthening the line. A small increase in line length produces a large and potentially hazardous increase in sag. For example, for a line with a 500 foot tower spacing (a typical span for overhead transmission lines) and an aluminium conductor steel reinforced (ACSR) conductor, a temperature increase of about 120.degree .F will causes about 6.4 inches increase in line length, which will increase the sag by about 4.7 feet. For the purpose of this calculation, line tension at 40.degree. F. was set to 20% of the conductor breaking load (a common practice by the transmission line designers).

A. *Hazardous effects of sag*

The problem of sagging power lines is well known to the electric power industry and is associated with problems which are hazardous and which are both time consuming and expensive to rectify. Sagging power lines pose an electrocution hazard to persons and vehicles and can lead to interruption in power supply and are known to cause hugely destructive and expensive forest and brush fires.

B. *Electrocution hazards*

Each year 3.6 percent of the deaths of youths under age 20 on farms are caused by electrocution? Electrocution is quick and deadly and is one of the most overlooked hazards of farm work. The most common cause of electrocutions are portable grain augers, oversized wagons, large combines, and other tall equipment that come into contact with overhead power lines. The same problem of sag also affects all other suspended structures such as bridges, suspended telecommunications wires and structural cables. (not really for this case!). Such wires and cables include cables used in construction of buildings and bridges.

Figure 1: High Voltage Transmission Lines

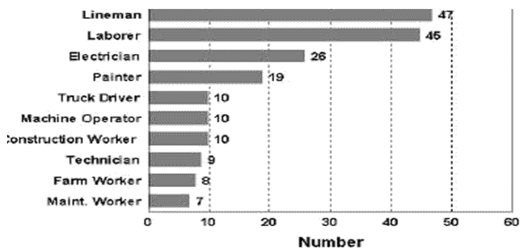

Figure 2: Bar graph showing the deaths caused due to electrocution

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Additionally the same problem may affect any wire that is under tension, such as guide wires and cables used for transmitting force from a control to an instrument such as may be used in boats and aircraft and cars and other machines too.

Present techniques to compensate for such sag caused by undesired increase in length of a cable include:

1. Shortening the distance between adjacent towers to reduce span length and thus reduce line sag.
2. Erecting taller transmission towers to accommodate line sag.
3. Replacing exiting conductors with new ones with lower sag characteristics.
4. Retro-fitting existing towers to increase height.
5. Limiting electrical current load capacity to compensate for increased ambient temperature.
6. Other methods for reducing sag and for keeping a suspended line taught include the use of constant tension elements such as springs and pre-stressed tensioners and even the use of strategically placed weights on the suspended line.

C. *Need of temperature monitoring*

To provide electricity without interruption to a growing economy is a challenge for power engineer. This has to be cost effective, harmless to the environment and should also meet the requirements of the dynamic industries.

The reasons for temperature monitoring of power cables are:

1. Hot spot location and monitoring.
2. To compare installation conditions.
3. Control cooling systems
4. Determine circuit rating.
5. Manage overload operation.
6. Maximise power capacity.

To summarise we can say that temperature monitoring of power cables offers the following advantages:

1. Means to monitor the cable condition since rise in temperature indicates an insulation breakdown or a change in its operating environment.
2. Option of comparing the load to temperature changes and the actual temperature can be compared to theoretical values.
3. Ability to postpone circuit investment, since if the cable temperature is known in relation to load, maintenance and replacement can be properly scheduled according to its behaviour rather than doing prediction.

Figure 3: A Transmission Tower

D. Effect of environmental conditions on transmission lines

1. Temperature rise will increase precipitation. In winter, an increase in 'maximum snow precipitation' is to be expected. This would lead to more severe snow and ice deposition on power line structures.
2. Temperature rise results in an increase in thunder storms and consequently lighting strikes on power lines.
3. Periods with unfrozen ground will increase. This has the positive effect that it facilitates working at underground lines during a longer period of the year. However, it will increase the frequency of weather conditions combining high wind speeds, snow, and unfrozen ground. Such a combination bears a high risk of falling trees, possibly damaging power lines.
4. An increase of days with temperatures of 30°C and more**.** Distribution transformers are calculated for an ambient temperature of 20°C corresponding with a transformer hot spot of 98°C. Ambient temperatures of above 30°C leading to hot spots of more than 110°C would seriously affect the life expectancy of those transformers.

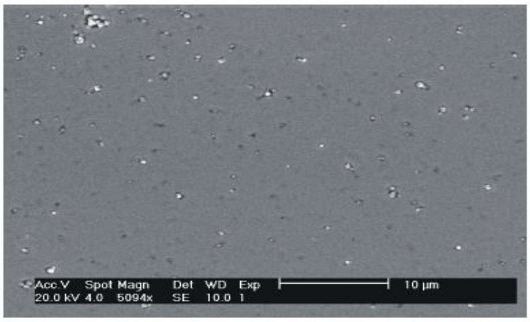
II. EXPERIMENTAL PROCEDURE

A. PLZT-BASED TEMPERATURE SENSOR

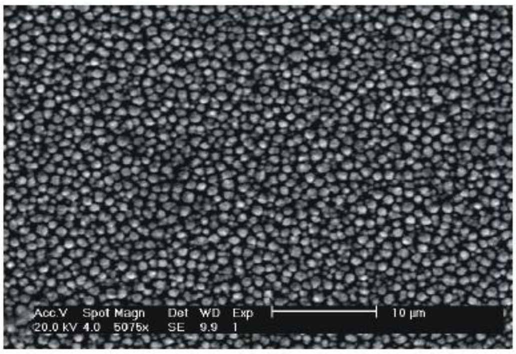
The compounds of the solid-solution $PbZrO_3$ –$PbTiO_3$, called PZT shows strong piezoelectric effect and have same structure as Pervoskites. The piezoelectric properties depend on the Ti/Zr ratio.

A very important material obtained by incorporating Lanthanum into PZT shows both piezoelectric as well as electro-optic effects .This new group of material is known as PLZT, where usually Pb is replaced by La.

Erbium doped PLZT ceramic powders with La:Zr:Ti with proportion 9:65:35 were obtained through conventional solid states reaction .The mixture is mixed in a ball mill for three hours ,using distilled water and ZrO_2 cylinders as grinding media .It is then dried ,and the mixed powder was calcined in



(a)



(b)

Figure 4: SEM Micrographs of PLZT deposited with Substrate heating at different temperatures.

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air at 900^{0}c for three hours to form Pervoskites phase. After this process the powder was remilled for 10 hour to reduce the particle size.

B. *Properties of PLZT*

1. High chemical stability,
2. High mechanical and thermal resistances,
3. Good piezoelectric coefficients and
4. Enhanced sensitivity.
5. Easy and fast fabrication using **MEMS** Technology.
6. Cost effective.

C. *Fabrication of the sensor:*

A lead lanthanum zirconate titanate (PLZT) thin film was coated on nickel foil by chemical solution deposition on nickel foil.

- This sensor can be designed by **IntelliSuite** (the first commercial CAD for MEMS tools) which optimizes **MEMS designs** prior to fabrication, reducing prototype development cycle time and cutting manufacturing costs.
- IntelliSuite also contains Piezo MEMS module which has the following features:
  1. Piezoelectric and piezoresistive modelling
  2. Linear and non-linear models.
  3. Piezo-acoustic coupling and high frequency analysis.

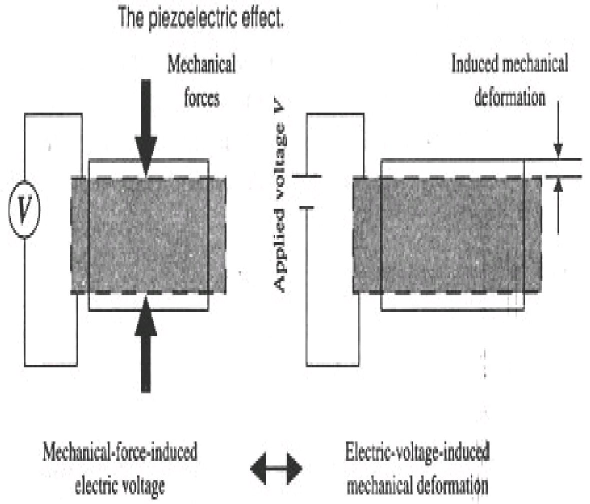

Figure 5: Basic principle of piezoelectric effect

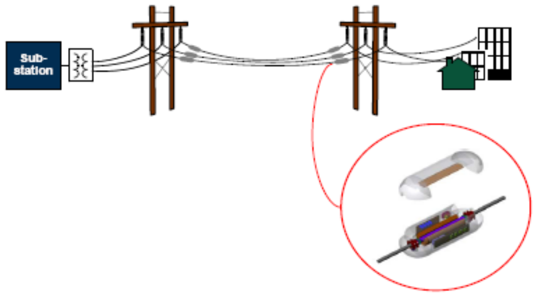

Figure 6: PLZT temperature sensor fixed in the power cable.

III. RESULT AND DISCUSSION

The sensed signals are to be transmitted to the control station for proper monitoring. Transmitters are electrically connected to the temperature sensor and the tension sensor for reading the output of the temperature sensor and tension sensor and transmitting signals indicative of the sensor outputs. A processor including a receiver for receiving signals indicative of the sensor outputs of the temperature sensor and the tension sensor, and calculating the average temperature of the section of power conductor based upon computing the real time covariance of these signals is also employed.

IV. CONCLUSION

Hence the PLZT based Temperature Sensor; fabricated using MEMS technology can be a promising device for the future applications having numerous advantages. It can be utilized as a device which will be helpful to monitor the temperature and sag in electrical transmission lines even in adverse environmental conditions.

Due to the recent trends in MEMS technology we hope that this sensor will be broadly implemented. Due to the enormous application potential, it might be reasonable to hope that large scale fabrication methods of PLZT based sensors will be developed, resulting in decrease in the cost.

The most important feature of this project is that this has a high social relevance. We can reduce the electrocution hazards and transmission losses by continuous and proper sag monitoring. This will also enhance proper power transmission and alsodetect the increase in load even in the peak hours. As this proposed method is also cost effective, we can ensure that power will be delivered in the remotest places without any risk.

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