International Journal of Advanced Science and Technology
Vol. 29, No. 12s, (2020), pp. 1982-1990

Power Transmission Lines Cooling in Under Ground Cables and Overhead Lines

G. G.Ramakrishna Prabhu [1], K.Vidhya[2] And Dr. R. Thamilselvan[3]
[1]Associate Professor, Department of Electrical and Electronics Engineering, Vinayaka Mission's KirupanandaVariyar Engineering College, Vinayaka Mission's Research Foundation (Deemed to be University), Salem-636 308, TamilNadu, India
[2]PG Scholar, Power Systems Engineering, Department of Electrical and Electronics Engineering, Vinayaka Mission's Kirupananda Variyar Engineering College, Vinayaka Mission's Research Foundation (Deemed to be university), Salem- 636 308 TamilNadu, India
[3]Professor, Department of Information Technology, Kongu Engineering College, Perundurai, Erode, India – 638 060

[1] krishprabhugovind@gmail.com,
[2] thamilvidhya@gmail.com,
[3]r_thamilselvan@kongu.ac.in

Abstract

The transmission line cooling system is a necessary technique to cool down the transmission network to improve the power transmission efficiency. This real time transmission line cooling system that replaces existing aluminum core into copper core. Temperature sensor is used to monitor copper coil's energy and monitors the parameters of transmission line load current and voltage. External coolant oil / water is used to maintain the constant temperature at transmission line. The oil-filled cable is used widely with the higher voltage ratings, and it was known that the central duct is adapted for internal cooling. The development of internally cooled cables, based on the self-contained oil-filled cable together with a full range of accessories and ancillary equipment is proposed.
Keywords: Transmission Line, Copper Conductor, Coolant Oil

1. Introduction

A pipe-type cable with high-pressure, oil-filled, system is made up of several cables enclosed in a steel pipe and it is used for underground electrical power transmission. The cables are made with a copper conductor wrapped with porous, a protective outer covering and oil-soaked paper insulation. The dielectric oil is filled between the pipe and cables which is under high pressure. The oil, which impregnate the paper covering on the cables that provides electrical insulation for the cables and also transfers the heat generated by losses in the cables to the pipe and neighboring earth at the same time. Pressurization of the oil prevent vapor formation in the paper insulation and insures proper electrical padding of the cables. The capacity of power transmission of underground cables is limited by the maximum allowable conductor temperature, which in turn depends on the rate of heat removal from the system. For oil-filled pipe-cable circuits, the forced cooled systems have recently been considered. The chilled oil is transmitted all the way for absorption of heat generated in the cable throughout the transmission line.

The main objective is to maintain constant temperature and increase the efficiency of Transmission line and to reduce the heat dissipation due to the below 2 cases.
Case1: Temperature rise due to Overload & Overcurrent.

Case 2: Temperature rise in transmission line is due to atmospheric temperature rise & it depends on climatic conditions.

2. Problem Identification

- Overhead leads to insulation failure
- Reduced resistance
- Conductor snapping leading to interruptions
- Usage of high capacity conductor for heavy load.

Condition

- Cooling of Transmission lines limit by coolant during overheat alone.
- Maintain constant temperature range
- Improve the performance of Transmission lines.

In the refrigeration stations, the hot oil is circulated through the cooling system. By using forced cooled system, the current carrying capacity of underground cable systems can be improved. In a forced cooling system the heat dissipated from the underground cable insulation to the surface of the cable. By a combination of natural and forced convection heat is transmitted from the cable to the oil.

If the present system is tested, the values of the temperature circulation in the underground cable with forced cooling can be simplified to a study of the transmission effects in the insulation. The convective resistance must be experimentally calculated but the results of the transmitter resistance can be designed analytically. The heat transfer in oils is very long in the region of way in special effects for enforced convection, hence the measurement of combined strained and natural convection is complicated to carry out the analysis.

A natural convection test on the full sized system was made to evade the model and the input from transmission line problems, since enforced convection should enhance natural convection heat transfer, the thermal opposition for natural convection alone should be higher than the thermal opposition for combined natural and forced convection. If the thermal resistance for natural convection is much smaller than the conduction through the cable insulation, then it is reasonable to assume that the thermal resistivity for combined natural and forced convection should be less significant than the conduction resistance.

3. Conventional Method

Introduction

The range of quantity will be larger than the convection resistance from cable surface to the oil. Therefore, to accurately predict the cable heat through conduction within the insulation must be accurately represented whereas a accurate calculation of the convection outside the cable is not necessary. The result for the conduction within the insulation must include causes due to cable joints and the nearness of one cable to another. The commonly used method is three cables spaced in an equilateral triangular configuration with stagnant oil trapped between the three cables. A confined oil space is formed by two cables and the pipe, the temperature conditions are not as severe since the pipe forms a rather good conduction path between the cooler oil and confined oil outside the confined space.

Explanation

The common method is spacing of three cables in a triangular shaped arrangement with stagnant oil trapped between the three cables. The temperature conditions are not as severe since the pipe forms a rather good conduction path between the confined oil and cooler oil between the conductor spacing when two cables and the pipe will form a confined oil space. The power carrying capacity of a cable is reduced to the maximum allowable temperature of the insulation, which in turn depends on the rate of cooling done from the system. Through conduction the heat is dissipated in the conductor from the cable insulation to the surface of the cable. In a forced cooled system the heat is transferred from the cable surface to the oil by a combination of forced and natural convection. Finally the heat will pass from two resistance connected in series, the paper insulation and outer surface of the underground cable.

When convective heat transfer can be negligible when compared to the conductive resistance through the insulation, the calculation of the cable temperature can be simplified to a study of conduction effects in the insulation. These can be solved by straightforward analytical techniques. If the convective resistance dominates, then complicated experiments are needed to accurately measure the convective heat transfer resistance. Although dependable capacity of convective heat transfer for the underground cable-pipe geometry is not available, convective results for simplified geometries presented in heat transfer reference, indicate that the convective resistance should be smaller than conductive resistance. To substantiate this, exact measurements of convective heat transfer are necessary.

Advantages

- The calculated pipe and oil temperature, and electrical heat input were used to calculate the heat transfer coefficients.
- The heat dissipated from the cable surface must be transferred across the non-flowing oil,
- The triangular configuration of three cables is most severe case with sluggish oil trapped between the three cables.

Disadvantages

The lowest calculated values were taken for the heat transfer coefficients in the oil.

4. Proposed Method

The design relates to a method and related apparatus for cooling power transmission cables, wherein a coolant for cooling the power transmission cables is introduced into a pipe which envelopes Cryo resistive or super conducting transmission cables which cables each have conductors provided with coolant ducts therein.

The coolant flows through the coolant ducts in the conductors of the transmission cables and absorbs the heat generated in the conductors, the warm coolant is recovered at appropriate points along the transmission cable and transmitted via a return pipe or pipes installed along the cable and cold coolant is introduced into succeeding sections of the transmission cable so as to cool the succeeding sections of the cable conductors and a central cooling station for cooling, introducing and recovering coolant is installed at one end of the return pipe, to enable the entire transmission cable line to be cooled by a single central cooling station.

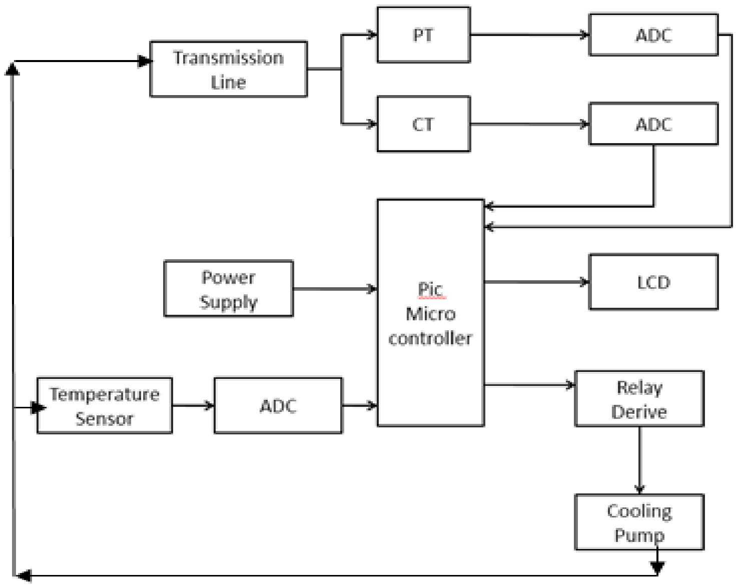

Fig 1.Power transmission lines cooling system block diagram.

International Journal of Advanced Science and Technology
Vol. 29, No. 12s, (2020), pp. 1982-1990

Explanation

The factors affecting the choice of fluids for internal cooling of cables have previously been considered and reported by other authors. It was decided to limit the investigation to the use of those coolants which remain liquid over the required temperature range so that, from theoretical and practical considerations, the effective choice was reduced to two water and cable dielectric oil. In a practical cable installation the section length that can be cooled by the fluid is of prime importance. This length is dependent on the quantity of heat to be extracted, the permissible temperature rise of the cable and coolant, the physical properties of the coolant and the coolant flow rate. The flow rate is dependent on pressure head and duct diameter. Appendix 12 gives the general thermal and hydraulic theory governing internal cooling. It also develops the concept of relative cooled-section length for comparing coolants.

A comparison between the section lengths which can be cooled by water and some oil-filled cable. It will be seen that the relative cooled-section length for water is about twice that obtainable with the best mineral-oil coolant. While this is advantageous, the difference is not so great.as to enable a complete end-to-end cooling system to be used on most practical installations where lengths in excess of 5 km may be required. Water cooled cables and other electrical plant are in service at much lower voltages. However, a coolant is always introduced and removed at the ends of the conductor system where relatively long Cree page paths can be provided to reduce the electric stress on the water.

5. Hardware Description

Micro Controller

PIC micro controller is master in our project. PIC is used to read the temperature value using temperature sensor in transmission line. It consists of 8 analog channel for our project we used one analog channel that is pinA0. And also it will display temperature value in 16*2 LCD display. Whenever transmission line goes in to abnormal temperature that time it will active dc pump motor? This pump motor transmits cooling oil in copper tube.

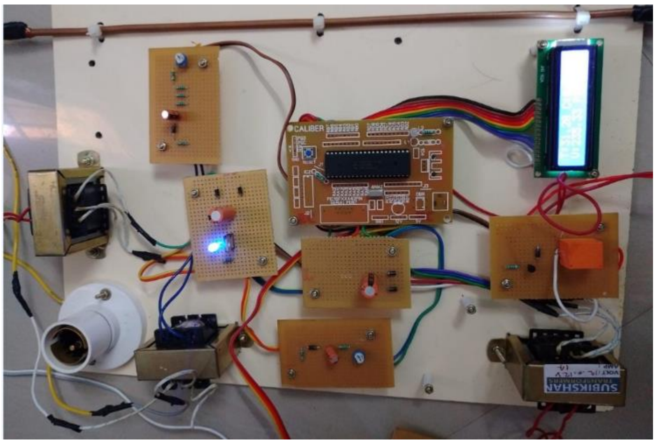

Fig 2. Hardware Setup

LM35

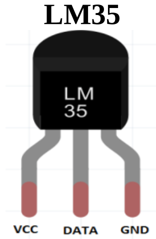

Fig 3. LM 35 Pin Diagram

The LM35 has three pins – VCC (Pin 1), Out (Pin 2) and Ground (Pin 3). The VCC and Ground pin are connected to VCC and ground respectively. The LM35 can be supplied a voltage between 4V and 20V, so a 5V supply is used on it same which is powering the pic micro controller. The out pin of the LM35 is connected to A0 pin of PIC controller the since the output from the LM35 is analog in nature.

It can measure temperature from -40° to 150° C. The voltage output from the out pin of the sensor is directly proportional to the temperature in degree Celsius. The voltage output increases or decreases by a factor of 0.01 V per degree Celsius rise or fall of temperature. The sensor has an accuracy of +/-0.4°C to +/-0.8°C.

Relay Driver Circuit

12v dc relay is used to turn on/ turn off dc pump motor. Whenever transmission line beyond the threshold temperature level micro controller activates relay through transistor.

LCD Display

It is used to show temperature value, voltage, current, connected load power and also cooling pump **on /off** status.

Circuit Diagram

12-0-12v step down transformer is used to provide power supply to whole circuit. 12v ac is then converted into dc supply by using rectifier circuit.7805 voltage regulator regulates 16v dc into 5v dc constant voltage. Lm35 sensor is connected to pic micro controller analog pin of pinA0. Load current can be measured with the help current transformer that is connected to pin A1. LCD display can be connected into B port of pic micro controller. Relay driver circuit connected into pin D0. CCS c compiler is used to develop program for our project. The compiled program can be verified via proteus simulation after that the program will be loaded into micro controller with the help of Pickit2 programmer.

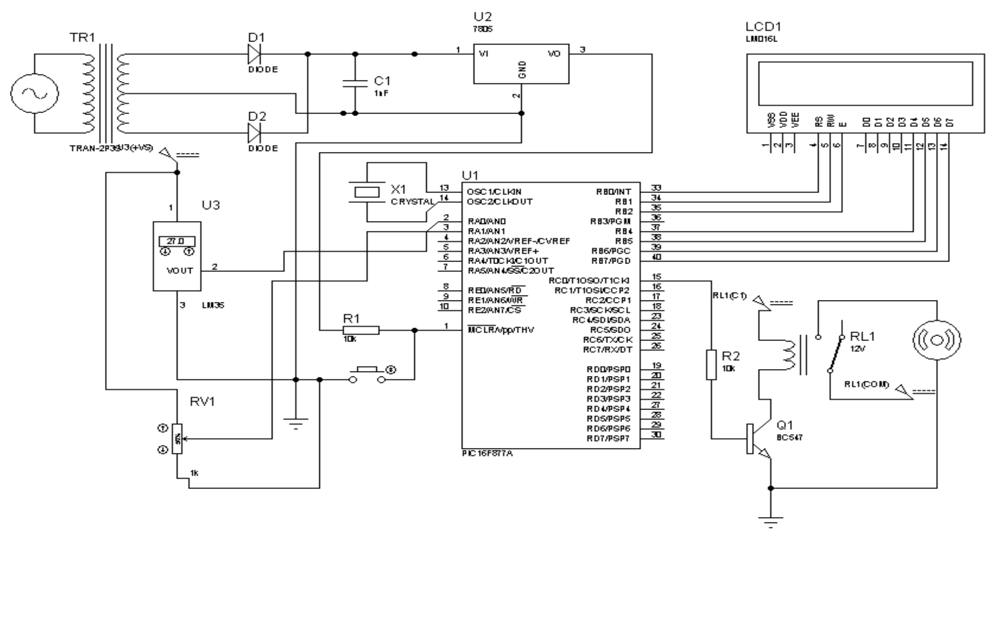

Fig 4. Circuit Diagram

ADVANTAGES

- Economical transmission of the bulk power
- It reduces corona effect and skin effect
- Leakage current will be minimized.
- Good conducting strength that helps to decrease the number of conductors.
- Reduce the loss due to heat,

Disadvanatges

Implementation cost is high compared to existing aluminum conducting core.

Application

- ✓ Power plant cooling system.
- ✓ UG cable loss minimization.
- ✓ Industrial motor cooling system.

6. Results and Discussion

In Fig 5. Temperature level is 34.70°C, Current is 0.27A, Voltage is 234.60 V and the Total Power is 65.35Watts.

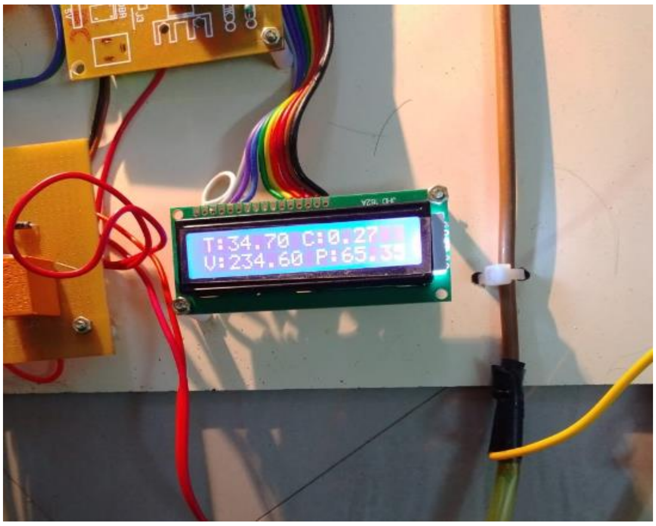

Fig 5. Result1

Whenthe temperature exceeds beyond 40° C the cooling system gets ON and the relay driver starts the cooling pump .The oil from the tank starts to flowing through the coolant pipe until the Temperature gets reduced below 38°C.

Fig 6. Result2

Fig 7. Result3

In Fig 6 & 7 the Current value is 0 so the Power is also zero in no load condition.

Fig 8. Result 4

In fig 8. The real time temperature Value is read using the [LM 35] temperature sensor and the value varies based upon the temperature.

7. Conslusion

The internally oil-cooled cable offers a cable system capable of meeting the highest transmission ratings with one cable per phase. Its use offers considerable way leave advantages and economy in cost, and it gives some 40—50% reduction in effective capacitance and dielectric losses as compared with the use of two cables per phase. The feasibility of the cable system has been proved in development and the practicability of circulating oil through the channels of a specially designed stop/feed joint has also been established. This has been confirmed by the long-term tests reported in the companion. The stop joint itself was found to be satisfactory on test but has shown that improvements are possible to reduce the overall mass of the joint components while increasing the capacity of the joint in respect of conductor sizes now available. This development is essential to the commercial adoption of an internally oil cooled cable to this system.

References

1. Endacott J.D., Flack H.W., Miranda, F.J., Mott, C.W., and Nicholson J.A.: 'The design development and application of internally and externally cooled cable systems for 275 kV and 400 kV, in 'Progress in overhead lines and cables for 220 kV and above'. IEE Conf. Publ. 44,1968, pp. 196-205
2. Arnaud U.C., Burton J., Crockett A.E., and Nicholson J.A. The development and trials of the 400 KV integral pipe cooled e.m.v. cable system', (see p. 286)
3. Barnes J., Anderson J.K.: Some aspects of oil circulated in the 'internal cooling of high power e.h.v. oil filled cables' in 'Progress in overhead lines and cables for 220 kV and above'. IEE Conf. Publ. 44, 1968, pp. 206-212
4. J. H. Parker, Jr. and M. P. Krefta, “The Intrinsic Magneto-Resistance of Cryogenic Joints,” IEEE Transactions on Applied Superconductivity,Vol. 7,
5. Z.J.J. Stekly, H.H. Woodson, A.M. Hatch, L.O. Hoppie, and E. Halas.IEEE Transactions on Power Apparatus and Systems.
6. P. Thullen, J.C. Dudley, D.L. Green, J.L. Smith, H.H. l. Woodson, IEEE Transactions on Power Apparatus and Systems
7. K. Ueda, T. Ageta, and S. Nakayama, “Super-GM and Other Superconductivity Projects in Japanese Electric Power Sector,” IEEE Transactions on Applied Superconductivity,
8. M. Rabinowitz, “Stored Field Superconducting Electrical Machine and Method,” [2014]
9. Dr.P.Selvam, Mr.G.Venkatesan, “ Power Quality Improvement in High Current with low Utility Voltage Power Generation System Through IOT” in Journal of Applied Science and Computations” Volume VI, Issue IV, pp 3641 -3647, April 2019, ISSN No: 1076-5131.
10. Dr.P.Selvam, “Optimal Wireless Power Transfer for Electrical Vehicle Battery Charging” in Journal of Applied Science and Computations” Volume VI, Issue V, pp 3641 - 3647, May 2019, ISSN No: 1076-5131.
11. D. Baskar, P. Selvam, “Electrical Transmission Line Fault Detection and Classification using Convolution Neural Networks and Support Vector Machine” Test Engineering & Management, Volume: 82, January-February2020, Page No. 6803-6808
12. R.Sankarganesh**,** P. Ashok Kumar (2019), “Mitigation of Harmonics and Power Quality Improvement for Grid-Connected Wind Energy System using Unified Power Flow Controller Based on Spontaneous Energy Optimization Algorithm” in International Journal of Engineering Inventions, Volume 8, Issue 1, pp. 92-101, ISSN: 2319-6491.
13. Mr. D.Madeswaran, Dr.P.Selvam, , Analysis of Active and Reactive Power with Constant Speed Operation of Doubly Fed Induction Generator in Wind Mill”, in International Journal of Research in Engineering, Science and Management , Volume 2, Issue 2, pp 119-123, Sep 2019 , ISSN No: 2581-5792.
14. R. Devarajan, S.Senthilkumar “Wireless aided Protection for 110 KV Transmission Line to Improve the System Stability” in International Journal of Computer and Communication Engineering” Volume 4 Issue 4, [2016].

15. Dr. R. Devarajan, K.Anbumani, “A New approach for Phase to Phase Line Fault Analysis in Overhead Transmission Line Based on IoT”, in Journal of Applied Science and Computations” Volume-6 PP:1926-1934, [2019].
16. T.Murugan, R.Sankarganesh (2016), “Power Quality Improvement for Harmonic Elimination of Variable Frequency Drive” in International Journal of Emerging Technology in Computer Science & Electronics, vol 21, Issue 2, pp. 287-290, ISSN: 0976-1353.
17. S.Chinnasamy, R.Sankarganesh (2016), “Power Quality Improvement Of Grid Tied PV WithReduced Number Of Components For Standalone Application” in International Journal of Emerging Technology in Computer Science & Electronics, vol. 21, Issue 2, pp. 291-296, ISSN: 0976-1353.
18. Dr.P.Selvam, Mr.D.Anandan, “ Optimal Power Improved Method For Induction Heating Application With High Resonant Boost Inverter”, in Journal of Power Electronics and Devices , Volume 5, Issue 2, pp 17-23, May 2019 , ISSN No: 1076-5131.