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Experimental investigation of the conductor temperature of the underground cable situated in sand and pipes

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ABSTRACT:*The aim of this study is to present a new method for the underground cable installation. In this work, we have investigated the steady state temperature field when the underground cable 12/20 (24) KV located in three models (direct installation in sand, PVC pipe and an aluminum pipe). In addition, it shows the results obtained in three different models and comparisons were made between the three models. Also results show that the proposed method when the cable located inside an aluminum pipe can be decrease the conductor temperature compared with a PVC pipe.*
KEYWORDS: *underground cable, sand, PVC pipe, aluminum pipe, thermocouple type (k), DS18B20*

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I. INTRODUCTION

Underground power cable operates at the maximum possible conductor current. Heat dissipation from the conductor to the soil plays a key role in evaluating the performance of buried cable systems. The AMPACITY of the cable essentially depends on the conductor temperature.

For electrical engineering, the calculation of conductor temperature of the cable is related to the temperature obtained by using sensor or thermocouple. So the studies from [1] to [6] used the sensor and thermocouple in the practical measurements of the temperature.

II. UNDERGROUND CABLE MODELS

In this study provided a wooden box which was used to present three models of the cable installation. The various models are descripted bellow:

1. Direct installation in the sand.(model 1)
2. Inside a PVC pipe.(model 2)
3. Inside an aluminum pipe.(model 3)

Fig.1 shows the actual scene when the cable located in the three models.

Fig. 1.The actual scene of the three models

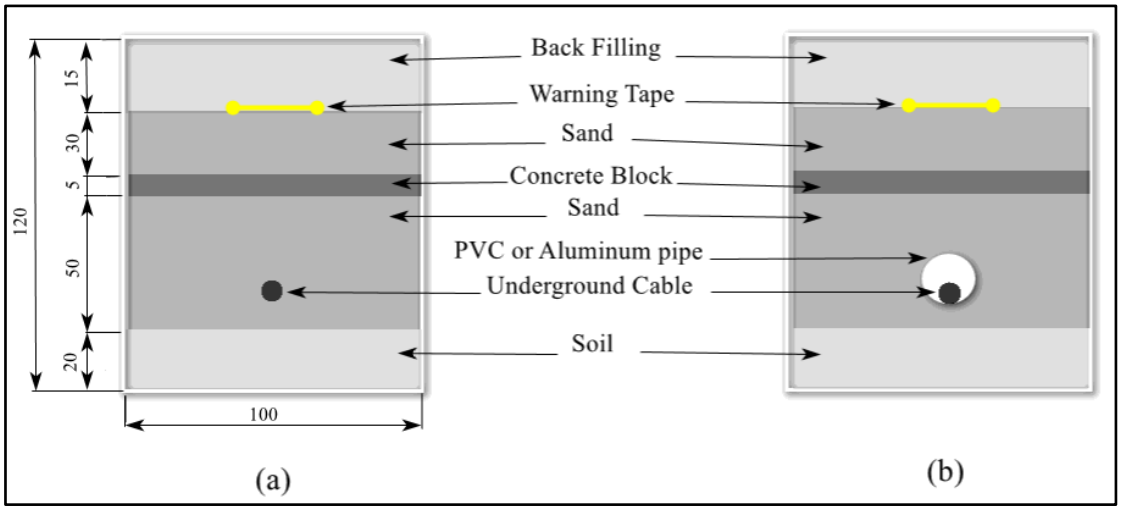


Fig. 2.Underground cable installations for the three models, all dimensions in cm

The system consists of a list of materials:

1. 12/20 (24) KV Single core cable, XLPE insulation with a copper conductor. The cable construction included 8 layers which are given in the figure bellow.

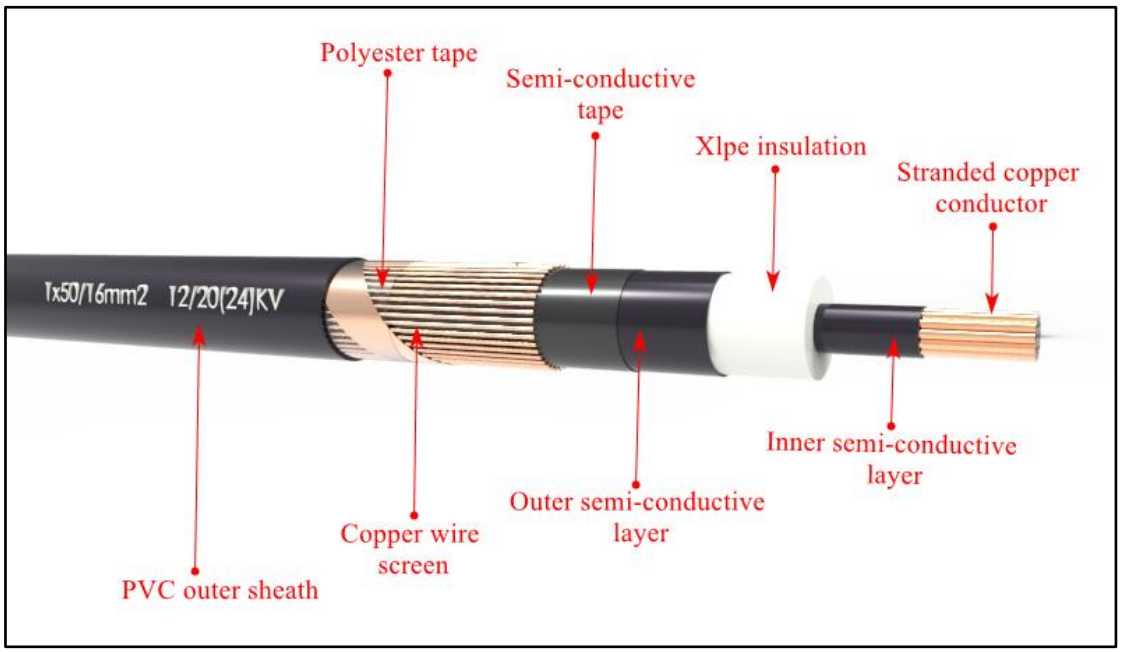


Fig. 3.Illustrate the construction of the cable

2. Wooden box which the 3 models located inside it. In addition, PVC pipe and an aluminum pipe were used in this study.
3. Two thermocouple types K for measuring temperature located on the Conductor and XLPE insulationrespectivelyas shown in fig.4, and UT321 thermometer was used to displays the temperature reading from thermocouples.

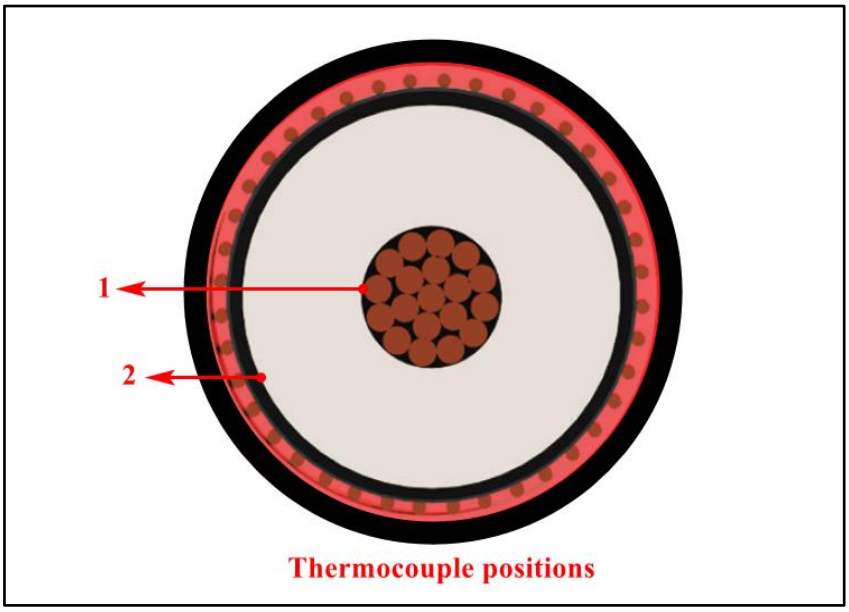


Fig. 4.The location for each thermocouple in the cable

4. Eight sensors of the (DS18B20) were used to sense the temperature of the [surface cable and sand], which is the soil around the cable exactly. In (model 1), four sensors are placed on the PVC outer sheath of the cable, and the other four sensors are placed around the cable as shown in fig.5(a) and (b) respectively. While in (model 2 and 3), four sensors are placed on the PVC outer sheath of the cable, and the other four sensors are placed around the pipe as shown in fig.5(a) and (c) respectively. The actual scene of the DS18B20 is shown in fig.1.

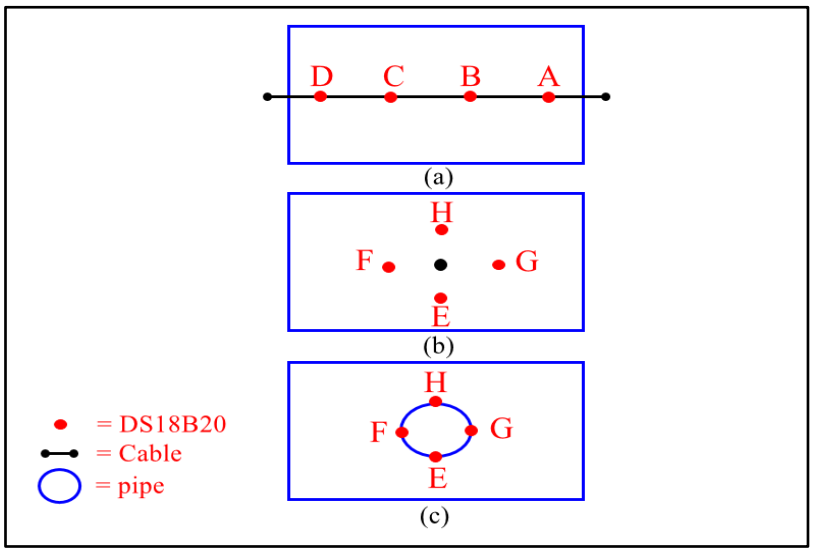


Fig. 5.The representation of the location for each sensor in (model 1, 2 and 3)

5. ARDUINO MEGA 2560 R3 was used as microcontroller and connect it to a computer with USBcable.In addition, serial monitor in the IDE Arduino was used to display the temperature readings from the eight sensors.
6. MEGGER MODEL DDA-6001 was used to provide the cable with the current required for the experiment.

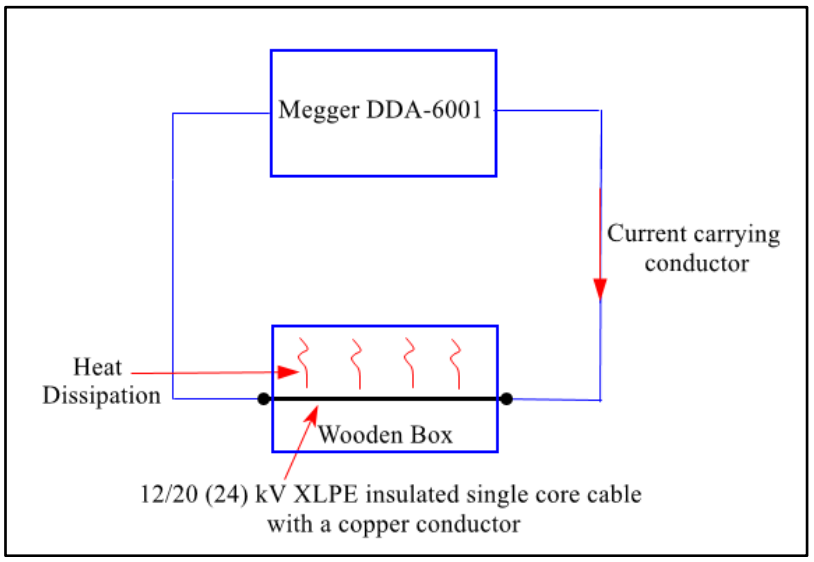


Fig. 6.Overview of the experimental structure

III. EXPERIMENTAL WORK

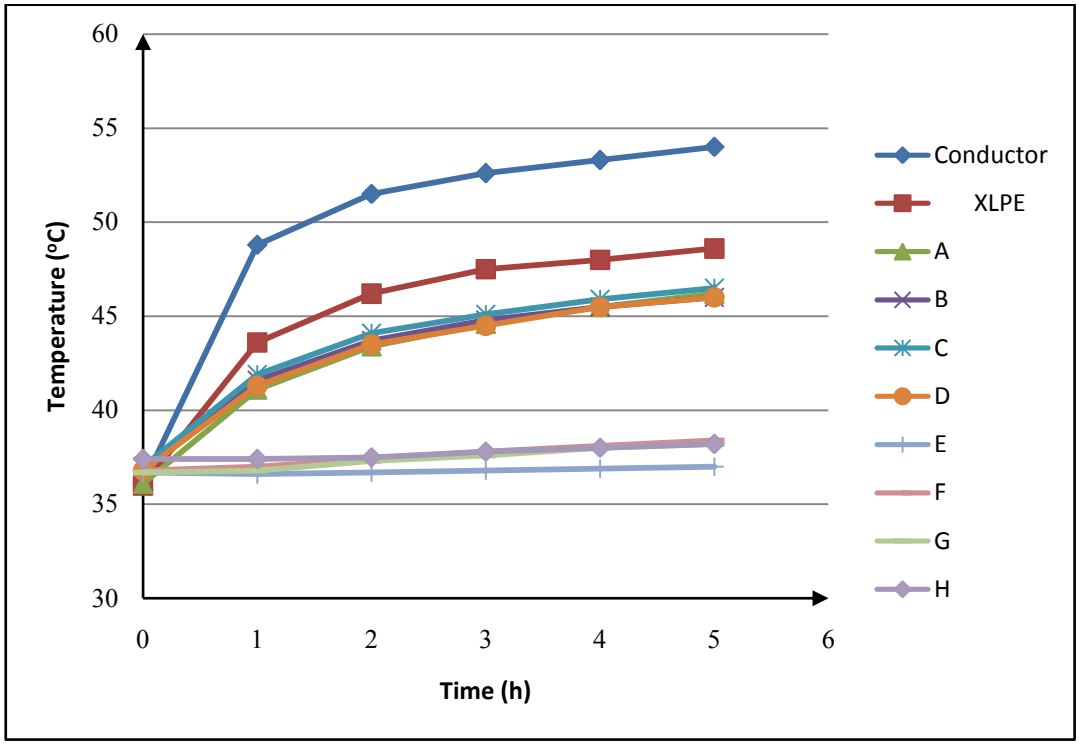
Table.1. Experiment schedule

Model	Environment	Burial depth (cm)	Test time (h)	Test current (A)
1	Direct installing in the sand	80	5	150
2	PVC pipe	80	5	150
3	Aluminum pipe	80	5	150

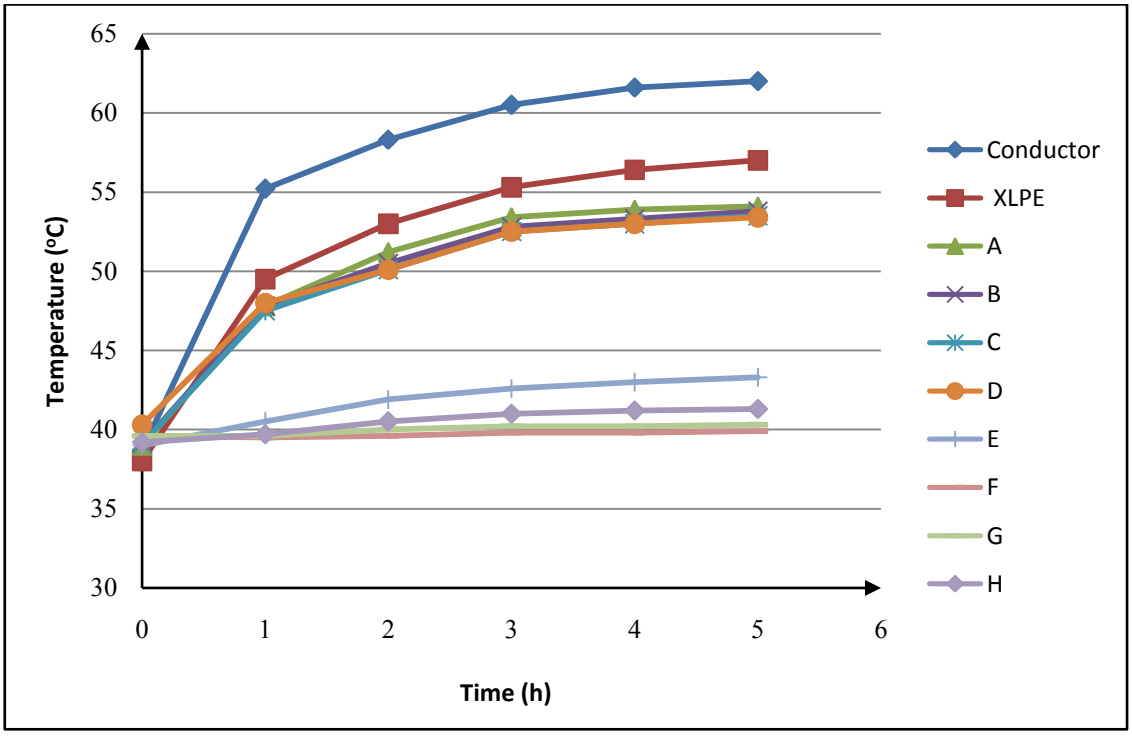
Each experiment started without current being loaded at a steady temperature condition, and it is worth mentioning that the process of thermal dissipation from the conductor, XLPE and to the PVC outer sheath of the cable was recorded every 1 hour.

IV. RESULTS

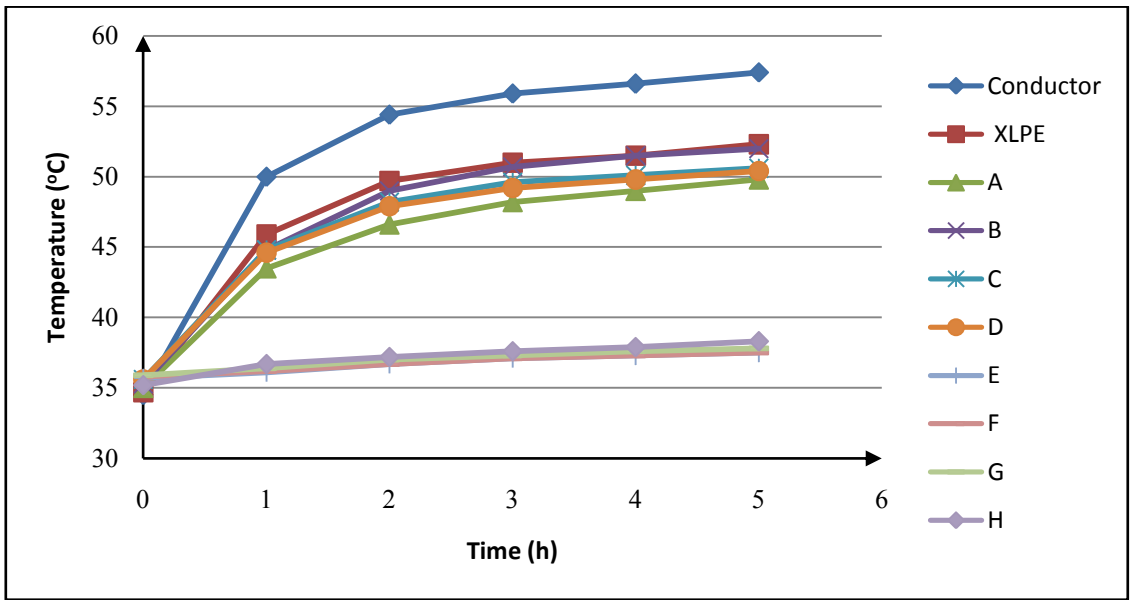
Heat generated in the cable is due to losses in the conductor, XLPE insulation and in the PVC outer sheath. Therefore, the results obtained from the three models dependent especially on the heat dissipation from the conductor, XLPE, PVC outer sheathand to the cable environment.Fig.7 shows the results obtained from model 1, 2 and 3 respectively.



(a)



(b)



(c)

Fig. 7.The variation of temperatures with the increase in time: (a) model 1; (b) model 2; (c) model 3

Fig.7compares the temperature differences for the results of the three models. It can be seen that from (model 1) the conductor temperature about (54°C) lower than (model 2 and 3). In addition, from (model 3) the conductor temperature to about (57.4°C) can be decreased compared with (model 2) which has the max conductor temperature about (62°C). Table.2 shows the comparison between the three models in the conductor temperature after 5 hours.

Table.2. The final value of conductor temperature after (5) hours

Model	Time (h)	Burial depth (cm)	Current (A)	Conductor (°C)
1	5	80	150	54
2	5	80	150	62
3	5	80	150	57.4

V. CONCLUSIONS

In this work, we have investigated the steady state temperature field when the underground cable 12/20 (24) KV located in three models (direct installation in sand, PVC pipe and an aluminum pipe). From the experiment it can be concluded that:

1. Lowest conductor temperature in the experiment was acknowledged in (model 1).
2. The proposed method (model 3) provided lower conductor temperature compared to the (model 2).

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