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Studies of the propagation of electric micro arcs on transmission and distribution cables

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ABSTRACT: Electric arcs are widely used in many applications and understanding or improving the corresponding processes or systems often requires precise modeling.
Access to electrical energy is an important issue for economic development and people's comfort. In Madagascar, this requires many improvements in order to achieve a satisfactory level of performance. In addition to the production, distribution and transmission of energy constitute a particularly critical issue. The study of the causes of failure highlights premature aging of lines, insulators and associated equipment compared to the behavior observed in temperate regions.
The study will be dedicated to the study of the appearance and propagation of micro electric arcs which constitute a major cause of equipment degradation.
First, we present the fundamental properties of thermal plasmas that are required in the models, followed by the model equations and structures. Then the existing climates in Madagascar
KEY WORDS: Electric arc, cable, temperature.

I. INTRODUCTION

This article is a contribution to the study of the propagation of micro electric arcs on distribution networks and associated systems.

On electrical power networks, the arc is one of the main causes of failures and damage to lines and associated systems such as distribution, transformation and switchgear. In tropical countries such as Madagascar, the appearance of these phenomena on the electrical network of the national electricity company are strongly linked to climatic conditions depending on the region.

The Navier-Stokes equation is used for modeling because the electric arc is a fluid and its movements can be described.

Propagation through transport and distribution conductors and cables depends on the electrical, mechanical and magnetic characteristics of these lines.
An experimental test bench was created to highlight the phenomenon with the different conditions of arc appearance. The study continues on the establishment of a typical predictive model of the phenomenon.
To interpret the result, a network analyzer and a thermal camera were used.

THE ELECTRIC ARC

[1]. The electric arc can be defined as an electric discharge passing through a gas between two conductors having a potential difference sufficient in relation to the ionization energy of the gases, the discharge being stable and self-sustaining.
[2]. Thermal plasmas are partially or strongly ionized gases, generally created by electric arcs at atmospheric pressure.
[3]. The behavior of the plasma flow being similar to a fluid, the equations used to describe the hydrodynamic movements are the usual Navier-Stokes equations.

EXPERIMENTATION

The work was carried out using an experimental device intended to reproduce an arc configuration. To obtain the arc, we made an experimental device comprising two electrode gates. The electric arc is then created from a HV transformer. The arc is struck by contact, bringing the cathode closer to the anode.

The electrical circuit whose diagram is given in the Figure below, is composed of a generator and a transformer. A switching device makes it possible to connect the secondary part of the transformer. When the device is powered up,

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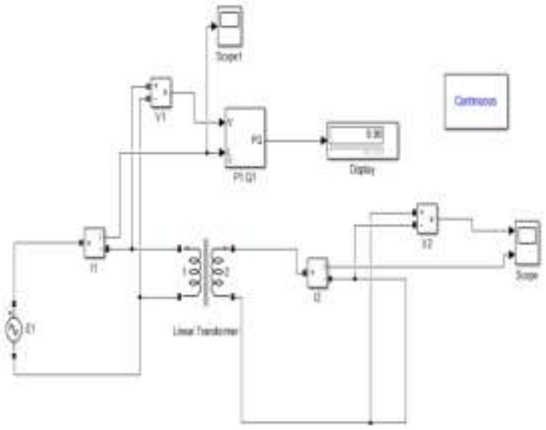
current flows first through the primary circuit and then to the secondary. We used measuring devices such as voltmeter, ammeter and oscilloscope to see the behavior of the transformer and the arc.



ASSEMBLY DIAGRAM

During the experiment, we put two 54.4 mm² almelec cables in parallel powered by a HV transformer. This first test was carried out in the open air, without taking into account the climatic conditions.

Here are the characteristics of the HV transformer: I = 2.5 A and U = 2100 V

The maximum arc temperature taken by the thermal camera is 366°C. The distance between the cables is 0.5mm

IMAGE BY THERMAL CAMERA

REAL IMAGE

MODELING BY ARB SOFTWARE:

ARB is free code designed by Dalton Harvie [4], released under the GNU General Public License (GPL). It uses the finite volume method to solve partial differential equations on unstructured meshes.

Simulation on ARB requires three files: name.arb, name.geo and name.msh

The name.arb file: it is created manually and contains a pseudo-program written in ARB language. The user defines in this file the constants, the variables, the unknowns, the equations to be solved and the boundary conditions. It must be associated with *.geo and *.msh files.

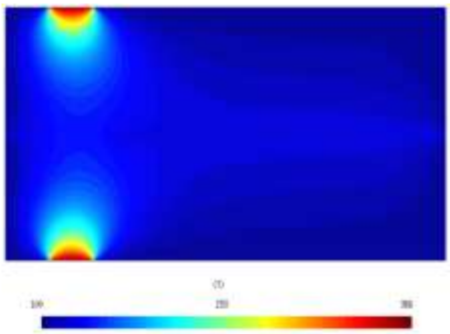
The name.geo file: this is a file created automatically by GMSH when creating the geometry. It contains the necessary geometry information and can be customized.

The name.msh file: this is a file designed by the GMSH mesh generator

Joule effect: The plasma is heated by Joule effect only in the area from the tip of the cathode to this section. Other authors have chosen not to represent the electric arc and to impose temperature and speed profiles at the anode outlet [5]. During the experiment, the maximum value of the Joule effect is 2.04×10^8 W/m² on each conductor.

Conservation of momentum: The axial and radial velocities constitute the convective term of the energy equation. They play an important role in getting the correct shape of the arch.

Temperature: The evolution of the arc temperature is represented by the following figures, its value varies between 366 to 177°C until the extinction of the arc.



TEMPERATURE 366°C

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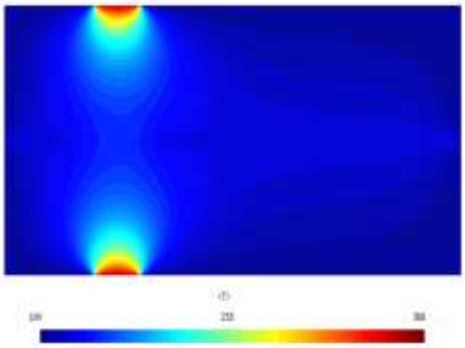
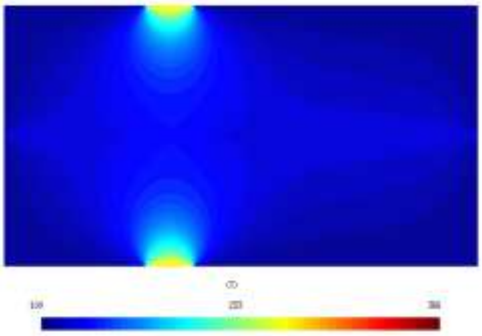
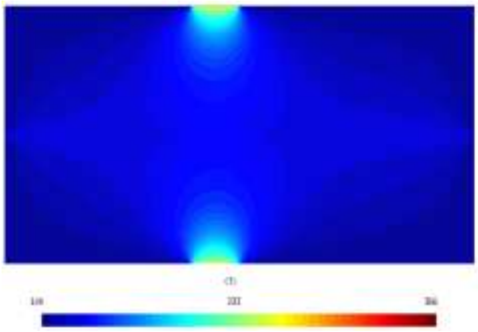


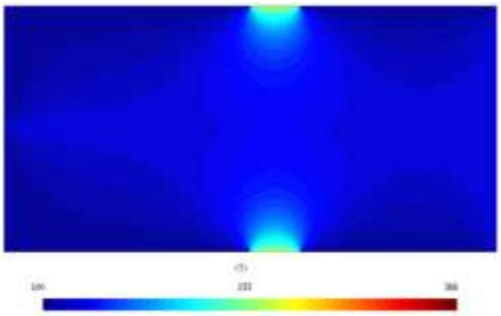
TEMPERATURE 356°C



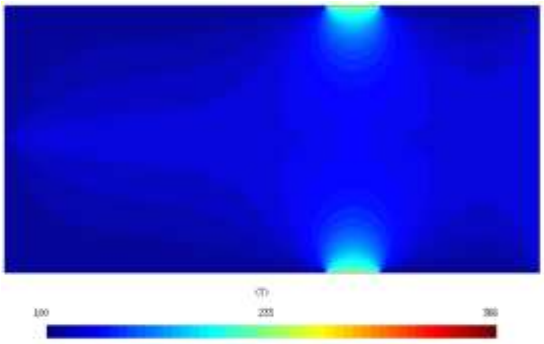
TEMPERATURE 277°C



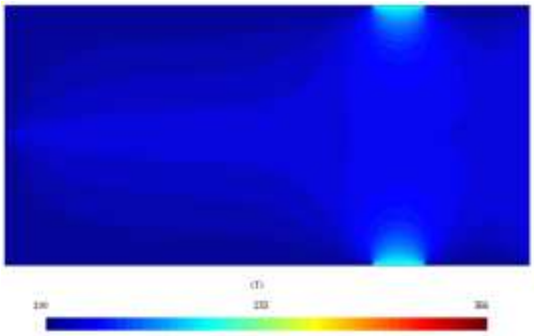
TEMPERATURE 252°C



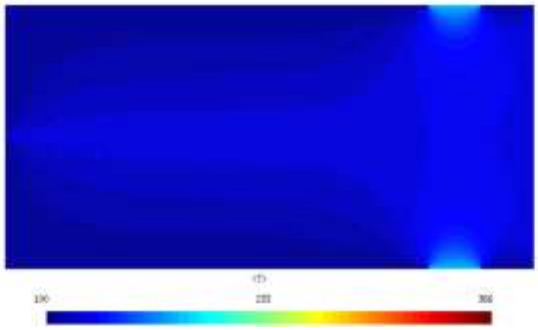
TEMPERATURE 239°C



TEMPERATURE 231°C



TEMPERATURE 198°C



TEMPERATURE 177°C

MESURES ELECTRIQUES
ELECTRICAL MEASUREMENTS

The measurement was carried out in air at ambient temperature and at atmospheric pressure, the arc being triggered by contact. For all measurements, the duration is 1 min.

At the beginning, there is first a period of short circuit followed by a small spark. The current then drops to a value close to zero, which is accompanied by an increase in voltage. When it is high enough the arc strikes. In some cases it is also possible to observe the triggering of the arc directly at the end of the short-circuit phase.

Depending on the case, a long arc may initiate or, on the contrary, a succession of short arcs may occur. Thus as we can see below an arc the first spark is 7 s, then after a new break of 5 s it reignites for 10 s.

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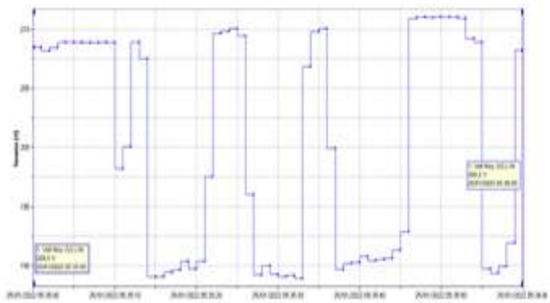
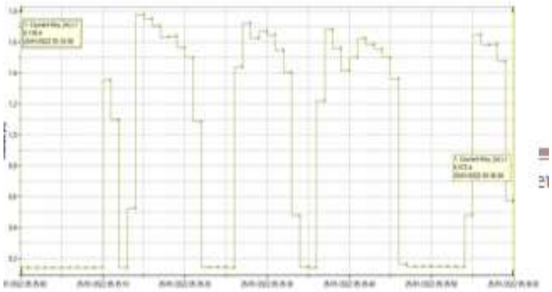
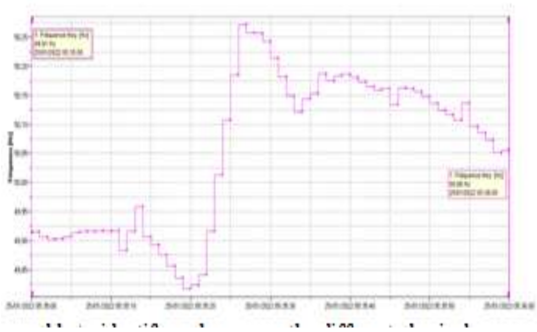
Voltage measurement: In general, voltage drops corresponding to successive sparks occur as soon as the power supply switches.
Current measurement: In the case shown in the following Figure, current peaks corresponding to successive sparks occur as soon as the power supply switches.
The electrical measurements presented in the following figure show an arc of 8, 7, 10 and 4s.



VOLTAGE CURVE



CURRENT CURVE



FREQUENCY CURVE

II. CONCLUSION

The objective is to study the electrical and thermal behavior of the electric arc in order to be able to identify and compare the different physical phenomena present between the conductors.

Our first personal contribution within the framework of this memory, was to design and to develop an experimental device making it possible to create an electric arc.

A test in the open air was carried out and a series of electrical and thermal measurements were carried out.

In daily life the electric arc presents us with some advantages such as arc lamps, arc furnaces, arc welding, spark plugs. But it also has disadvantages if it is not mastered well, such as fires and explosions.

This work constitutes the embryo of a long and vast study of electric arcs at the level of the EcoleSupérieurePolytechnique of Antatanarivo and even in Madagascar from an experimental point of view. There are many work prospects, such as the propagation of arcs on other types of conductors and arcs on insulators.

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