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Book of Abstract

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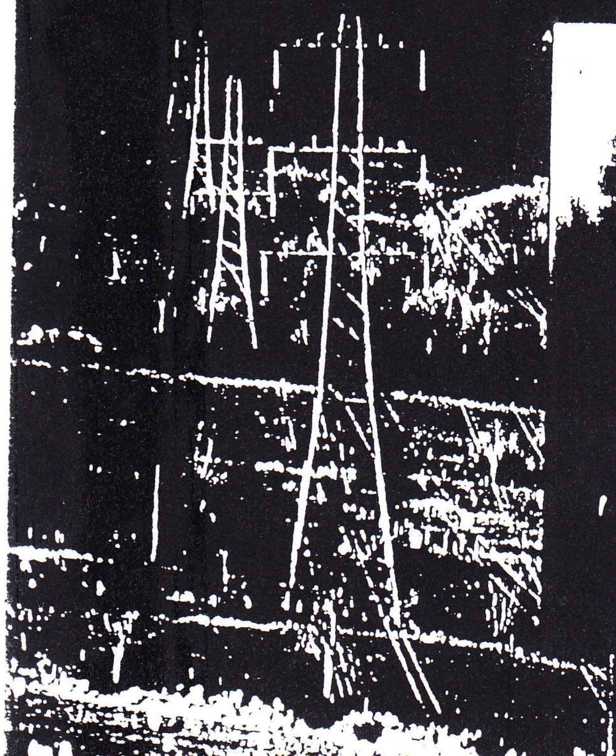

ANALYSIS OF CURRENT CARRYING CAPACITY OF OVERHEAD TRANSMISSION LINE USING FINITE ELEMENTS TECHNIQUE AND LIFE TIME OF ITS JOINTS

A.M. Ibrahim(1), M. A. Farahat(2), M. M. Abdel Aziz(1), M. A. Foda(2), M. M. Salama(2) and S. A. Abdel Moneim(2)
(1)Cairo University, Egypt, (2)Zagazig University, Egypt

ABSTRACT

The thermal behaviors of the overhead transmission lines and its connections are numerically investigated. The effect of the environmental conditions on the thermal rating of T.L is presented. A finite element technique is applied to the two dimensional transient conduction equations with different actual boundary conditions for both the transmission line and its connections. Both experimental and numerical studies are carried out. Measurements of the radial temperature distribution is conducted on a T.L of cardinal design at operating current of 200 A. The comparison between the present predictions with the present measurements for the cardinal base design shows good agreements. Also, the present theoretical model was modified to cope with T.L connections and the two dimensions temperature profiles are obtained at different operating conditions. A new correlation between the radial temperature difference and the operating current is obtained which may be a new factor that must be taken into consideration while loading transmission lines. Life time of overhead transmission line is calculated by using ageng mechanisms. The factors affected on the life time is presented. The effect of the environmental conditions (actual weather, dusty and / or very low temperature conditions) is found to be more effective on the T.L rating especially at high loading conditions. The wind speed is an effective parameter on the thermal behavior of T.L. The temperature difference between the center and surface of the T.L is found to be dependent on the loading current, T.L geometry and the wind speed. The presence of a thin layer of pollutants increases the temperature level. The increase in the oxide layer thickness tends to increase temperature rise, which leads to mechanical failure of the T.L. Therefore, this thickness must be minimized as possible.

1 INTRODUCTION

In most of the developing countries the demand for electric power is increasing yearly, and there is a corresponding requirement to increase the power transferred by transmission and distribution lines. A solution would be to build new lines but this may not be feasible on account of economical and environmental considerations. Hence there may be pressure to increase the load transfer capacity of the old lines as well as the new ones. The conductor temperature depends on the load current, the electrical characteristics of the conductor, and the ambient parameters such as wind and solar radiation. The relationship between these parameters is known as the heat equation. The heat equation for two-dimensional transient conditions was examined within the present work. The main objective of this work is to investigate the thermal effects of the flow of electric current with different intensities through the T.L with different designs at different weather conditions [1,2]. In the experimental part of this work, measurements of temperature distribution through the conductors were carried out at a loading current of 200 A. In the analytical part of this work, a finite element technique was adopted for the two dimensions condition equation to predict the temperature distribution through stranded conductors at both transient and steady state conditions. The effect of weather conditions and environmental conditions were investigated. Also, the present model was modified to predict the temperature distribution through the T.L connection [1]. A method for determining transmission line ratings based on the relationship between the conductor's temperature and its sag is presented in Ref. [1]. This method is based on the ruling span principle and the use of transmission line tension monitoring systems. To calculate the radial current distribution and core loss within a concentrically steel – cored conductor, the magnetic properties of the core must be known. The effect of magnetic field strength, tensile stress and temperature on the modulus, real and imaginary part of the complex relative permeability, the hysteretic angle, the loss tangent, the total core loss and the hysteresis loss, are illustrated by comprehensive measurements [3]

2 EXPERIMENTAL SET UP

The transmission line is the primary medium by which electrical power is transmitted within a power system. The function of overhead lines is to transmit electrical energy, which causes temperature rise on it. A test was constructed to realize the change in the temperature of transmission line during current passing through it. The present test section is formed from 7 steel strands surrounded by 54 aluminum strands and each of which is 2.7 mm in diameter. Fig. (1) shows a layout for the present test section, which represents an overhead T.L. The test line is fed with a constant current flowing from a current injector who is connected to the 220 Volts supply. The temperature at each steel and aluminum layer is measures by using copper Constantine thermocouples of 0.5mm diameter. The points of measurements and their leading wires are connected to a Data Logger. The following steps are processed in each run: adjustment of current injector, adjustment of data logger and set on of the current injector. The following readings are measured and recorded for each test run: reading of current and recording of the data logger output. The data logger automatically records both steel and aluminum temperatures at different measuring locations.

3 RESULTS

The radial temperature distribution across the transmission line as well as the axial temperature

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1 INTRODUCTION

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3 RESULTS

The radial temperature distribution across the transmission line as well as the axial temperature distribution along transmission line's connections were predicted and discussed. In fact, the transmission lines may extend along a wide area of different environmental conditions, which may contain different pollutants of different types. Therefore, it needs to study the effect of these different pollutants on the transmission line behavior. The actual weather performance of the transmission lines including the effect of wind speed, dust accumulation and ice formation on the outer surface is also investigated.

3.1 RESULTS OF TRANSMISSION LINES

The radial temperature distributions through the transmission line cross section were experimentally measures and theoretically calculated. The transmission line is subjected to an A.C of 200 A at room conditions with zero wind speed (U_w = 0). Fig. (2) shows the experimental measurements of the surface and center line temperature distribution across the transmission line, T_{al} and T_{st} respectively. Also, the theoretical predictions at the same conditions are shown in Fig. (3). It is noticed in Fig. (2), with the increase of operating time the temperature and the temperature difference between the transmission line center and its surface increase until they reach steady state values. A comparison between the experimental data and the present prediction are performed to check the validity of the present theoretical model. The comparison shows an acceptable agreement and assures the validity of the present theoretical model and the method of calculation. The wind effect on the transmission line performance is shown in Fig. (4) at 700 A of the loading current. It is clear from this figure that, both the centers line temperature and the outer surface temperature decrease with the increase in the wind speed. Also, as wind speed increases the transient time decreases especially at the surface. This is because the increases of the convective heat transfer coefficient. In practice the transmission lines are extended along very wide distances, they pass through industrial dusty, humidity, and very low temperature weather zones. Therefore, dust with different types may be accumulated on the outer surface of transmission lines. The actual weather performances of the transmission lines include the effect of dust accumulation and ice formation on the outer surface is investigated. The dust accumulation can be classified into dust of cement, dust of sandstone and dust of coal powder. The effect of the presence of the dust of cement layer with a thickness of 1 mm is shown in Fig. (5) at different wind speed and at 700 A loading current. It was found that, the presence of cement layers on the outer surface of the transmission lines behave as thermal insulators and thus in general increases the transmission line temperature level. A comparison between the effect of different types of pollutants layers (cement, coal powder and sandstone) of 1mm thick on the transmission line surface temperature at a loading current of 700 A is shown in Fig. (6). Especially for the transmission lines that passing through very cold area at which the ambient temperature drops under zero temperature a layer of ice may be formed around the outer surface of the transmission lines. The ice layer thickness depends on the ambient temperature and the wind speed. In the present analysis, a thin layer of 1 mm thickness is considered and the results are shown in Fig. (7) at different wind speed at a loading current 700 A.

3.2 RESULTS FOR TRANSMISSION LINES CONNECTIONS(ACSR CONDUCTORS):

Fig. (8) shows the axial steady state temperature distribution along the connection zone at different loading currents of 200, 500 and 700 A. It is illustrated that the transmission line temperature at contact zone decreases along the clamp length till it reaches a preside value at a distance apart from the clamp. At the contact zone, due to the sudden increase in the current intensity, the temperature reaches a higher value such that an aluminum oxide layer can be formed. Unfortunately, this aluminum oxide layer results in an additional increase in the transmission line temperature at the contact zone due to its higher electrical resistivity. The effect of oxide layer thickness on the contact zone temperature at a loading current of 700 A is shown in Fig. (9). This may also cause an increase in the oxide layer, which may lead to transmission line failure. The contact width effect on the contact temperature is shown in Fig. (10). It shows that as the contact width decreases the temperature at the contact zone increases. This is attributed to the increase in the current intensity, which increases the rate of heat generation at the contact zone. The transmission line over heating at connection zone can be avoided as much as possible by increasing the contact width via increasing the contact tightening force and thus in accordance enhances the clamping behavior. The temperature distribution through the contact zone for the proposed connection for different values of the air-gap width is shown in Fig. (11). It is noticed that, as the air gap increases the temperature level increases especially at the locus of the maximum temperature. This may be attributed to the thermal insulating effect of the presence of the air gap, which in accordance increases with the increase in the air gap.

4 LIFE TIME OF TRANSMISSION LINE CONNECTIONS

The length of the life time of T.L connections given by the time at the end of which either the insulation of the contact by oxidation is complete (break of contact) or when the softening temperature of the metal is reached. When an electrical contact is put into service, it is of importance to predict its probable length of life with respect to its operating temperature. The life time of electrical connections is affected by some factors [4] such as the contact clamping force, the joint length, the loading current and the initial operating temperature of the contact. On the basis of the analysis and results mentioned in references [4,5], it is evident that the life time of electric connections is mainly depending on the contact resistance of the connections. The dust particles cause electric contact failures, which seriously influence the reliability of the electric systems. Therefore, a layer of dust, which can cover the surface, should be

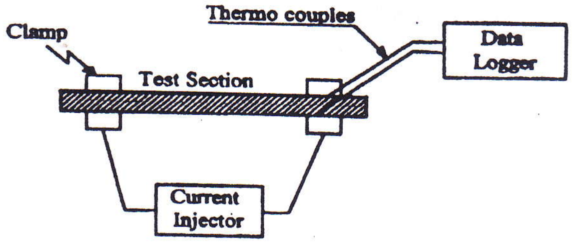

Fig. (1) The test section

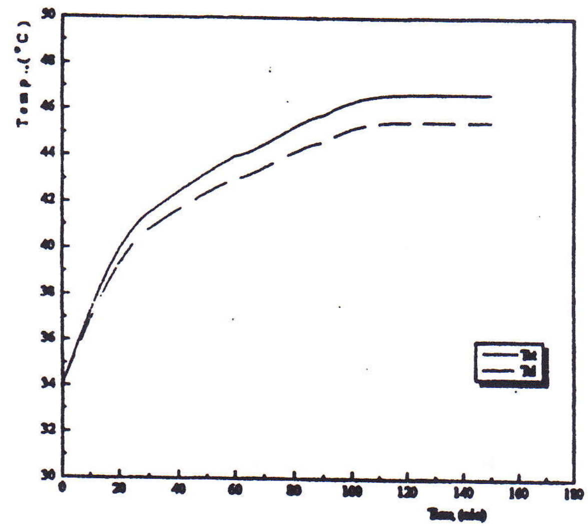

Fig. (2) Expermantal data for transient tempreture profiles aluminum and steel layers, clean T.L.at a current of 200 A and Uw = 0 .

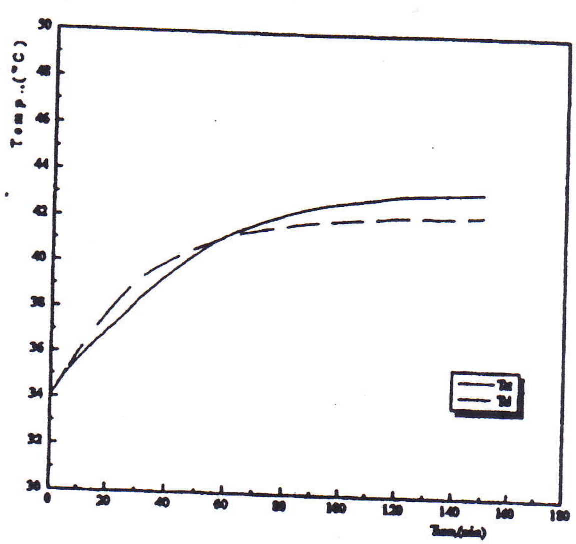

Fig. (3) Theoretical transient tempreture profiles aluminum and steel layers, clean T.L. at I = 200 A and Uw = 0 m/s .

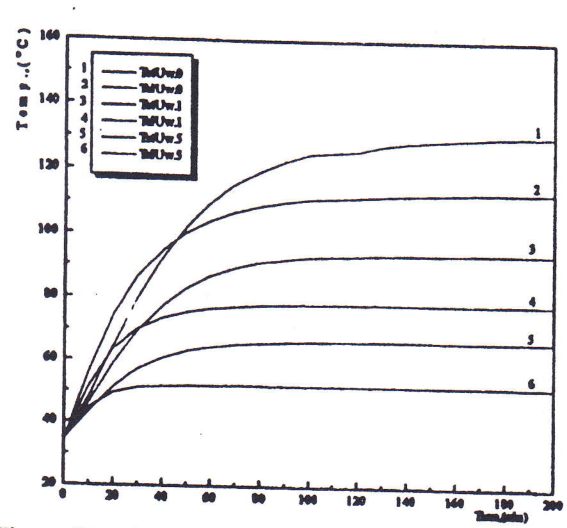

Fig. (4) Transient tempreture profiles for clean T.L.at a current of 7200 A and Uw = 0,1,5m/s .

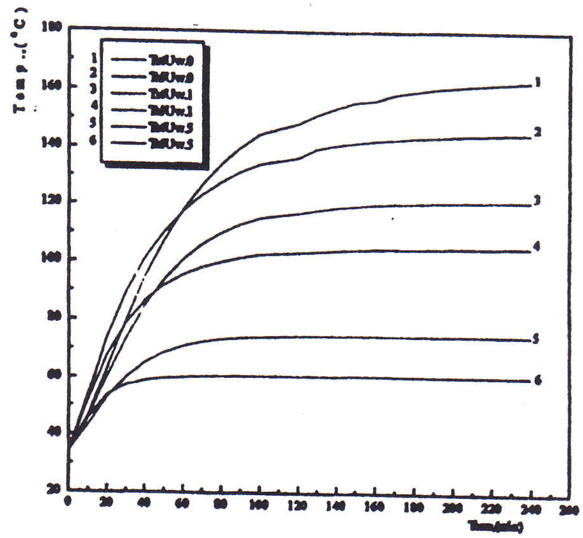

Fig. (5) Transient tempreture profiles for T.L.with 1 mm cement layer, at a current of 700 A and Uw = 0,1,5 m/s .

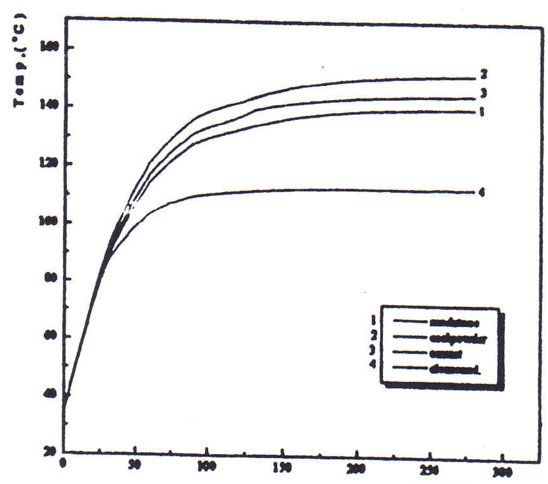

Fig. (6) transient surface tempreture for T.L.with 1 mm layer of different pollutants at 700A and Uw = 0 .

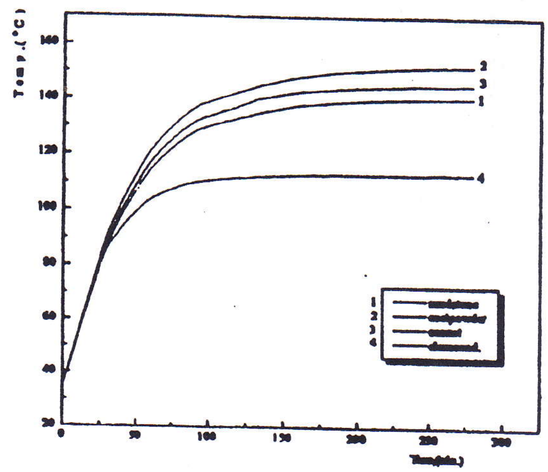

Fig. (7)) Transient tempreture profiles for T.L.with 1 mm ice layer, at a current of 700 A and Uw = 0,1,5 m/s

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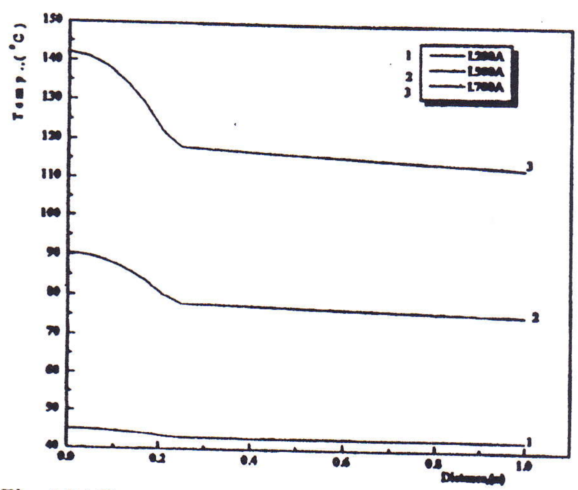


Fig. (8) Temperature distribution along the contact zone at different values of loading current for ACSR at steady state.

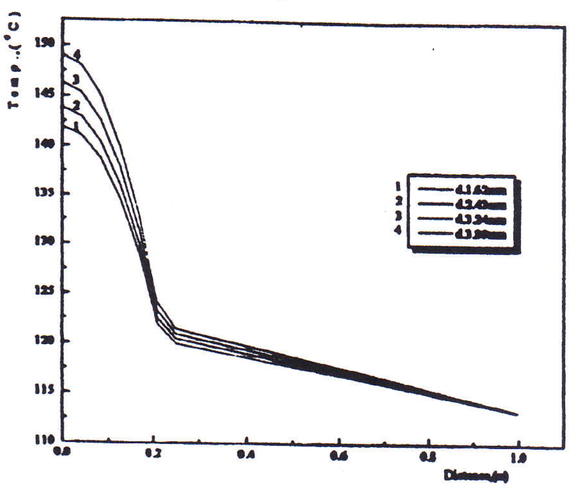


Fig. (9) Temperature distribution along the contact zone at different values of oxide thickness (d) for ACSR at I = 700A .

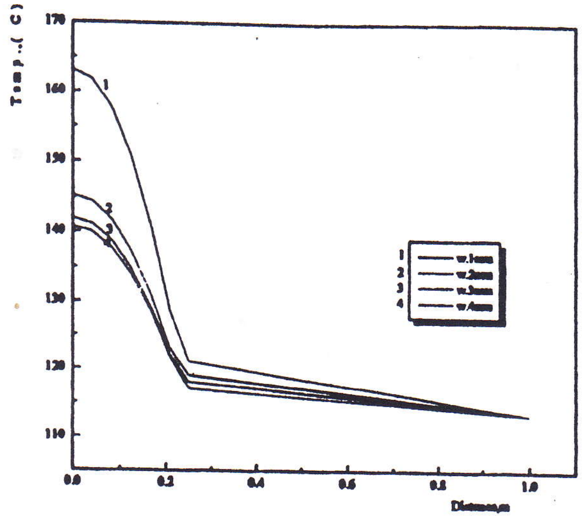
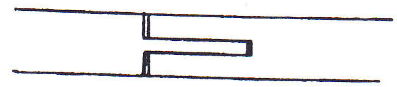


Fig. (10) Temperature distribution along the contact zone at different values of contact width (w) for ACSR at I = 700A.



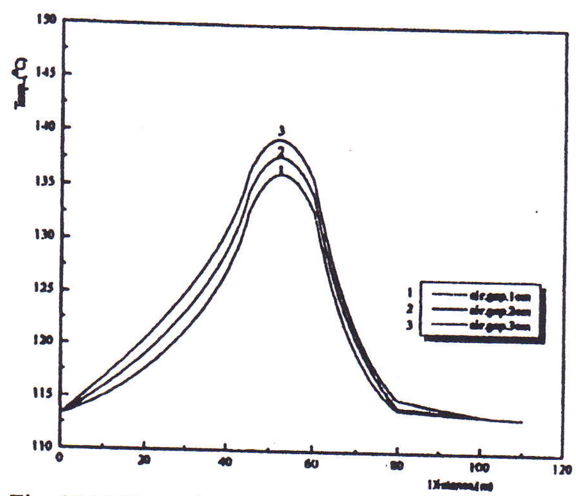


Fig. (11) Temperature distribution along the contact zone at different vâlues of air-gap width for ACSR at I = 700A.

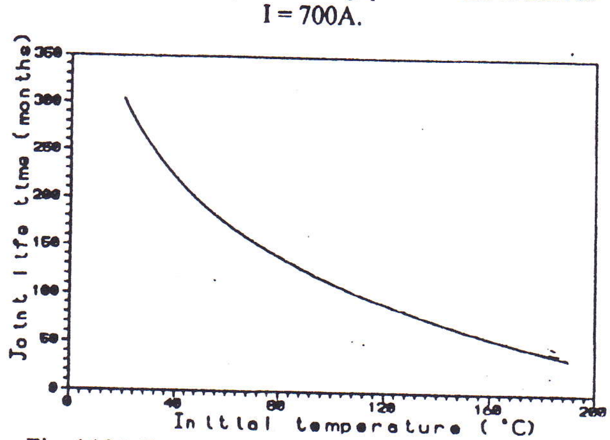


Fig. (12) Connection life time at different operating temperature prevented. The mixture of dust particles could be very harmful to the contact [6], especially under low normal force. In contaminated atmospheres, metal samples are subjected to dust and humidity so that corrosion of the surfaces will occur. The life time of the closed electrical contacts is affected by the main factors which may occur simultaneously [7]: Reduction in the a-spot section and increase in the oxidation layer at the contact. Running the computer program and calculating the life time of the connections at different operating temperature of the connections. It can be noticed that, the life time decrease with the increase of the operating temperature, which results in the increase of the contact resistance due to increase of oxidation film as shown in Fig. (12). Oxide films grow on the connection surfaces. When such corroded surfaces are in contact with each other, the contact resistance increases duo to current line constriction. Hence, the increase in contact resistance is generally attributed to corrosion film growth. So, the contact reliability is greatly degraded and the contact performance and life time are impaired. The temperature in the contact zone is directly related to the voltage drop across the interface. High operating temperature and humidity increase the rate of metal oxide formation at the contact surface. Hence, the contact resistance of the connection increases, and the life time decreases.

5 CONCLUSION

The comparison between the experimental data and the theoretical results shows an acceptable agreement in the steady state. It can be concluded that the present model is a satisfactory means for predicting the thermal behavior of transmission lines and their connections. The effect of the environmental conditions (actual weather, dusty and / or very low temperature conditions) is found to be more effective on the transmission line rating especially at high loading current. The wind speed is an effective parameter on the thermal behavior of the transmission line. Although the increase in the wind speeds decreases the transmission line temperature level. It has no significant effect on the radial temperature differences especially at low values of loading current. The temperature difference between the center and surface of the transmission lines is found to be dependent on the loading current, the transmission line geometry and the wind speed. The presence of a thin layer of pollutants increases the temperature level. The axial temperature distribution through the connecting clamp at the transmission lines connection zone is strongly affected by the following parameters: the loading current, the contact width, the thickness of the aluminum oxide layer and connection geometry. The increase in the oxide layer thickness tends to increase temperature rise, which leads to mechanical failure of the transmission lines. Therefore, this thickness must be minimized as possible. As the operation of any transmission line is limited by the loading currents, so the thickness of the oxide layer can be minimized making the contact area as wide as possible. The a-spot temperature rise in the contact zone is mainly a function of the voltage drop across the interface. The aging rate increases rapidly with increasing voltage drop across the interface. Thus the a-spot temperature is a very important parameter with regard to the aging of the connectors. The results of computer program indicate that both contact force, surface oxidation films and geometry play important roles in the electrical performance of aging connectors.

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06/09/00

To Whom It May Concern:

This is to certify that Prof. M E Mandour attended the UPEC 2000 conference and presented the following paper:

"Analysis of a current carrying capacity of over-head transmission lines using finite elements"

Dr. B Fox
UPEC 2000 Organiser

نموذج (I)

بيانات عن بحث مقدم للترقية

عنوان البحث (باللغة التي نشر بها) :

"Analysis of current carrying capacity of overhead transmission line using finite elements technique and life time of its joints"

مكان النشر (بلغة مكان النشر) :

35th Universities Power Engineering Conference, UPEC 2000, School of Electrical and Electronic Eng., Queen's University of Belfast, Belfast, Northern Ireland, 6-8 September 2000.

تاريخ الإرسال للنشر : تاريخ القبول للنشر : ٢٨ مارس ٢٠٠٠ تاريخ النشر : ٦-٨ سبتمبر ٢٠٠٠

- في حالة نشر البحث ترفق صورة البحث مأخوذة من المجلة العلمية أو مجلد المؤتمر مباشرة.
- في حالة قبوله للنشر يقدم أصل خطاب القبول للنشر .
- في حالة الأبحاث الملقاة في المؤتمرات يقدم ما يثبت أن البحث قد ألقي في المؤتمر .

ملخص البحث باللغة العربية (حتي مائة كلمة) :

تحليل سعة التيار لخطوط النقل الهوائية باستخدام العناصر المتناهية الصغر والعمر الافتراضي لوصلاتها

تم معالجة التصرف الحراري لخطوط النقل الهوائية ووصلاتها وتأثير الظروف البيئية علي المعدل الحراري لهذه الخطوط. وتم تطبيق أسلوب العناصر المتناهية الصغر علي معادلات التوصيل اللحظية ثلاثية الأبعاد تحت ظروف مختلفة لكلا من الخطوط ووصلاتها . كما تم إجراء دراسة عملية ودراسة تحليلية .وتم إجراء قياسات توزيع درجات الحرارة علي موصل "كاردينال" عند قيمة تيار ٢٠٠ أمبير ، وأظهرت المقارنة بين نتائج الدراستين العملية والتحليلية توافقا جيدا . وتم تعديل النموذج الرياضي ليتناسب مع التطبيق علي وصلات هذه الخطوط ، وتم الحصول علي معامل ارتباط جديد بين الفرق القطري لدرجة الحرارة وتيار الخط والذي يجب أخذه في الاعتبار عند التحميل .

وتم إيجاد العمر الافتراضي لخطوط النقل باستخدام أسلوب تقدير العمر مع مراعاة العوامل التي تؤثر علي هذا العمر . وتبين تأثير الظروف البيئية من حالة الطقس وسرعة الرياح وتراكم الغبار أو الجليد حول الموصل علي المعدل الحراري للخطوط خاصة عند ظروف التحميل العالية . وتبين من البحث أن فرق درجات الحرارة بين قلب وسطح الموصل يعتمد علي تيار التحميل ، الشكل الهندسي للموصل ، وسرعة الرياح وسمك طبقة الملوثات البيئية أو طبقة أكسيد الألومنيوم وأن ارتفاع درجة الحرارة يؤدي إلي التعب الميكانيكي للخطوط ويجب اختزال سمك هذه الطبقة قدر الإمكان. وبالنسبة للوصلات وجد أن التوزيع الحراري المحوري خلال الوصلات يتأثر بشدة تيار التحميل ، عرض منطقة التماس ، سمك منطقة الأكسيد ، وكذلك شكل الوصلات . ووجد أن الارتفاع في درجة الحرارة الموضعي عند منطقة التماس هو دالة في هبوط الجهد خلال منطقة التداخل. ويعد الارتفاع الموضعي للحرارة من أهم العوامل عند حساب تقدير عمر الوصلات . ووجد أن العمر الافتراضي يتناقص بسرعة مع زيادة الهبوط في الجهد خلال منطقة تداخل الوصلة. وتم عمل برنامج كمبيوتر يقوم بحساب العمر الافتراضي للوصلات من ناحية الأداء الكهربي مع الأخذ في الاعتبار قوة التلامس ، طبقة التأكسد السطحية والشكل الهندسي للوصلات .

إذا كان البحث يعتمد في أكثر أجزائه علي رسالة علمية :

عنوان الرسالة : رسالة دكتوراه تحت عنوان :

"تحليل سعة التيار للخطوط الهوائية باستخدام طريقة العناصر المحددة "

"Analysis of current carrying capacity of overhead transmission lines using finite elements"

اسم صاحب الرسالة : منار احمد عبد العزيز فوده

أسماء المشرفين علي الرسالة : ا.د. محمد ممدوح عبد العزيز - ا.د. محمد عبد المقصود عابدين

ا.م.د. محمد مؤنس محمد سلامه - ا.م.د. سيد احمد عبد المنعم

تاريخ قيد الرسالة : ١٩٩٢/١١/١٦ م تاريخ مناقشة الرسالة : ١٩٩٧/١١/٢٢ م

لجنة المناقشة : ا.د. محمد ممدوح عبد العزيز - ا.د.عصام الدين محمد أبو الذهب - ا.د. وجدي محمد منصور

- ا.د. محمد عبد المقصود عابدين ا.م.د. محمد مؤنس محمد سلامه

في حالة الأبحاث المشتركة يتم ملء الوجه الآخر من الاستمارة