PROGRAM BOOK

ICVEE 2022

2022 The Fifth International Conference on Vocational Education and Electrical Engineering (ICVEE)

THE FUTURE OF ELECTRICAL ENGINEERING, INFORMATICS, AND EDUCATIONAL TECHNOLOGY THROUGH THE FREEDOM OF STUDY IN THE POST-PANDEMIC ERA

September

10-11, 2022

UNESA

IEEE ComSoc

IEEE Communications Society

Welcome Message from the General Chair

ICVEE 2022 is the fifth International Conference on Vocational Education and Electrical Engineering organized by the Faculty of Engineering, Universitas Negeri Surabaya. This year, the theme of this conference is "THE FUTURE OF ELECTRICAL ENGINEERING, INFORMATICS, AND EDUCATIONAL TECHNOLOGY THROUGH THE FREEDOM OF STUDY IN THE POST-PANDEMIC". Following the theme, this conference aims to bridge the scientists, education experts and practitioners, and students in the scientific forum through sharing ideas and issues about theoretical and practical knowledge in electrical engineering, informatics engineering, engineering education and vocational education.

ICVEE 2022 is attended by presenters from overseas, such as the Brazil, Marocco, Germany, and Indonesia. Hopefully, we can have a productive conference with exciting and encouraging discussions, knowledge exchanges, and networking.

This conference will not be possible without tremendous supports and help from those who give their all-out efforts and hardworking. I am very grateful to all the organizing committee and scientific committee members for their outstanding work to support this conference. Through this conference, we wish to increase our knowledge and work together to advance technology for the humanities.

Sincerely yours,

Dr. Hapsari Peni Agustin T., S.Si., M.T.
Conference Chair
e-mail: hapsaripeni@unesa.ac.id

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ICVEE in a Glance

The International Conference on Vocational Education and Electrical Engineering (ICVEE) is an international conference hosted by Universitas Negeri Surabaya's Electrical Engineering Department.

The International Conference on Vocational Education and Electrical Engineering (ICVEE) began in 2005 with the introduction of the Seminar Teknik Elektro (STE). STE was born and later evolved into ICVEE as the era progressed. The first ICVEE was held in 2015. ICVEE 2020 and 2021 proceedings were published in IEEE eXplore in the last two years.

While the implementation in 2022 will be the fifth, 2022 The Fifth The conference will be held in Surabaya, Indonesia, inviting academics, researchers, and practitioners to submit case studies of practice, theoretical papers, empirical studies, and other papers that address any topic within the broad areas of Vocational Education, Electrical Engineering and Informatics. On this occasion, the conference's theme is “The future of electrical engineering, informatics, and educational technology through the freedom of study in the post-pandemic era”. IEEE Indonesia Section through IEEE ComSoc Indonesia Chapter will support ICVEE. Accepted papers will be submitted for inclusion into IEEE Xplore subject to meeting IEEE Xplore's scope and quality requirements.

Short Biography

Prof. Auzuir Ripardo de Alexandria

Affiliation
Instituto Federal de Educação Ciência e Tecnologia do Ceará: Fortaleza, CE, Brazil

Biography

Auzuir R. Alexandria has a degree in Electrical Engineering (1993) and a Bachelor's Degree in Computer Science (1994) from the Federal University of Campina Grande, a master's degree (2005), and a doctorate (2011) in Teleinformatics Engineering from the Federal University of Ceará. He is a professor at the Federal Institute of Education, Science, and Technology of Ceará – IFCE, Fortaleza campus, Industry department, since 2003. As a researcher, he works in the fields of Computer Vision, Mobile Robotics, Biomedical Engineering, Artificial Neural Networks, and Industrial Automation, coordinating and guiding several projects. He is the leader of the Computer Simulation research group at IFCE.

Areas of Expertise

Major Area: Engineering / Area: Electrical Engineering.
Major Area: Engineering / Area: Electrical Engineering / Subarea: Industrial Electronics, Electronic Systems and Controls / Specialty: Electronic Automation of Electrical and Industrial Processes.
Major Area: Engineering / Area: Electrical Engineering / Subarea: Computer Vision.

Major Area: Engineering / Area: Electrical Engineering / Subarea: Industrial Electronics, Electronic Systems and Controls / Specialty: Electronic Process Control,Feedback.

Major Area: Engineering / Area: Electrical Engineering / Subarea: Embedded Automation Systems.

Dr. Sven Schulte

Affiliation
TVET School
School administration of the city of Dortmund
Germany

Areas of Expertise:

Learning, Pedagogics, Teaching and Learning, Academic Writing, Pedagogy, Assessment, E-Learning, Educational Evaluation, Technology Enhanced Learning, Blended Learning

Prof. Dr. I Gusti Putu Asto Buditjahjanto, S.T., M.T.

Affiliation

Electrical Engineering Department of State University of Surabaya (Universitas Negeri Surabaya- UNESA), Indonesia

Biography

I.G.P.A Buditjahjanto has a degree in Electrical Engineering in Telecommunication (1998) from Institut Teknologi Sepuluh Nopember (ITS), a master degree (2003) in Industrial Engineering from ITS and a doctoral (2011) in Game Technology from ITS. He is a profesor at UNESA, Electrical Engineering department, since 2021. As a researcher, he works in the fiels of Computational Intelligent, Decision Support System, Education Engineering. He is a member of MCDM Society.

Areas of Expertise

Major Area: Electrical / Area: Electrical Engineering/ Sub Area: Computational Intelligent, Artificial Intelligent, MCDM, intelligent System/ Specialty: Optimization, DSS, Decision Making.

TIMETABLE

10th September 2022

MC: *Paramitha Nerisafitra*, S.ST., M.Kom

Roswina Dianawati, S.Pd., M.Ed

Zoom Link: http://unesa.me/ICVEE2022

Or

Zoom Link:

https://us06web.zoom.us/j/83315901773?pwd=ekl1ZnJiZnFEMXU0bHl4a1kyYnVZZz09

Meeting ID: 833 1590 1773

Passcode: 839188

Time (GMT+7)	Activity
07.00 – 08.00	Online Registration
08.00 – 08.05	Opening and Rule Guidance
08.05 – 08.10	Listening Indonesia National Anthem
	Listening Mars of Universitas Negeri Surabaya
08.10 – 08.15	Conference report by ICVEE chair
08.15 – 08.25	Welcome Speech from Rector of Universitas Negeri Surabaya Prof. Dr. Nur Hasan.M. Kes
08.25 – 08.35	. IEEE Comsoc Indonesia Chapter Chair Opening speech: Dr. Bambang Setia Nugroho
08.35 – 08.45	Advisory Board Committee Representative Speech: Prof. Nobuo Funabiki Okayama University
08.45-08.55	Photo session
PLENARY SESSION I	

09.00 – 09.50	**Keynote speaker 1** Prof. Auzuir Ripardo de Alexandria Instituto Federal de Educação Ciência e Tecnologia do Ceará: Fortaleza, CE (Brazil) Moderator : Pradini Puspitaningayu, S.T., M.T
09.50 – 10.40	**Keynote speaker 2** Prof. Dr. I Gusti Putu Asto B., S.T., M.T. Dept. of Electrical Engineering State University of Surabaya (Indonesia) Moderator : Dr. Yeni Anistyasari
10.40-10.45	Awarding Token of Appreciation I
11.00 – 12.00	**PARALLEL SESSION I** (5 breakout rooms) Room 1 – 5
12.00 – 12.30	BREAK
PLENARY SESSION II	
12.30 – 13.20	**Keynote speaker 3** Dr. Sven Schulte Scientific Researcher and Lecturer TU Dortmund University (Germany) Moderator : Dr. Lilik Anifah, M.T
13.20 – 13.25	Awarding Token of Appreciation II
13.25 – 13.45	Break
13.45 – 15.30	**PARALLEL SESSION II** (5 breakout rooms) Room 1-5
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Room 1

Moderator : Dr. Lilik Anifah

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2	2238	11.15-11.30	Evianita Dewi Fajrianti, Sritrusta Sukaridhoto, Nobuo Funabiki, Muhammad Udin Harun Al Rasyid, Rizqi Putri Nourma Budiarti and Yohanes Yohanie Fridelin Panduman	Design and Implementation of Indoor Navigation for PENS Visitors Using Augmented Intelligence
3	3145	11.30-11.45	Raymond Sunardi Oetama, Ford Lumban Gaol, Benfano Soewito and Harco Leslie Hendric Spits Warnars	When Candlesticks are different among Forex Brokers, can Traders still win?
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5	5178	13.45-14.00	Hapsari Peni Agustin Tjahyaningtijas, Laras Suciningtyas, Naim Rochmawati, Lusia Rakhmawati, Cucun Very Angkoso and Andi Kurniawan Nugroho	Brain Tumor Classification Using Deep Neural Network Based on MRI Images
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			Windie Velarde and Raymond Daylo	Evacuation in Municipal Disaster Risk Reduction and Management Office
7	6340	14.15-14.30	Surjandy Surjandy and Cadelina Cassandra	The Influence of Information Quality, Trust, and Risk Factors of The Digital Advertising on Buying Decision
8	7011	14.30-14.45	Yuni Yamasari, Anita Qoiriah, Naim Rochmawati, I.M. Suartana, Oddy Virgantara Putra and Andi Iwan Nurhidayat	Exploring the Kernel on SVM to Enhance the Classification Performance of Students' Academic Performance
9	9057	14.45-15.00	Yeni Kustiyahningsih, Eza Rahmanita, Devie Rosa Anamisa and Jaka Purnama	An integrated approach to determine mapping of SMEs during Covid-19 pandemic
10	9414	15.00-15.15	Evi Pane, Diah Risqiwati, Adhi Dharma Wibawa and Mauridhi Hery Purnomo	Gender Difference in EEG Emotion Recognition with Overlapping Shifting Window
11	9654	15.15-15.30	Cucun Very Angkoso, Ari Kusumaningsih, Hapsari Peni Agustin Tjahyaningtijas and Andi Kurniawan Nugroho	Multiclass Deep Transfer Learning for Covid 19 Classification

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2	2181	11.15-11.30	Yohanes Yohanie Fridelin Panduman, Nobuo Funabiki, Pradini Puspitaningayu, Masaki Sakagami and Sritrusta Sukaridhoto	Implementations of Integration Functions in IoT Application Server Platform
3	3087	11.30-11.45	Beatriz Silva Brasil, Auzuir Ripardo de Alexandria and Glendo de Freitas Guimarães	Artificial Intelligence applied to the classification of retinal diseases in Optical Coherence Tomography images
4	3229	11.45-12.00	Abdul Rahman Patta, Nobuo Funabiki, Yan Watequlis Syaifudin and Wen Chung Kao	An Implementation of Solving Activity Monitoring Function in Android Programming Learning Assistance System
5	6606	13.45-14.00	Pradini Puspitaningayu, Nobuo Funabiki, Yuanzhi Huo, Yohanes Panduman, Xinyu Wu, Minoru Kuribayashi and Wen-Chung Kao	Accuracy Investigations of Fingerprint-based Indoor Localization System Using IEEE 802.15.4 in Two-Floor Environment
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8	7992	14.30-14.45	Irin Tri Anggraini, Nobuo Funabiki, Pradini Puspitaningayu, Shih-Wei Shen, Wan-Chia Huang and Chih-Peng Fan	Implementation and Evaluation of Exercise and Performance Learning Assistant System Platform for Yoga Pose Practices Using Node.js
9	8015	14.45-15.00	Shintami Hidayati, Nafa Zulfa, Pima Safitri and Yeni Anistyasari	Exploring the Potential of Adopting Computer-graphics Animation to the Switch to a Plant-Based Diet
10	8979	15.00-15.15	Glenn Gumba and Jessie Paragas	PREDICTION ANALYSIS OF STUDENT ADMISSION TO INFORMATION TECHNOLOGY EDUCATION (ITE) PROGRAMS USING CLASSIFICATION ALGORITHM
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Room 3

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2	409	11.15-11.30	Rifqi Firmansyah	Power Sharing Control and Voltage Restoration in DC Microgrid Using PI Fuzzy
3	3634	11.30-11.45	Widi Aribowo, Reza Rahmadian, Ayusta Wardani, Mahendra Widyartono, Bambang Suprianto and Aditya Chandra Hermawan	Marine Predators Algorithm For Tuning DC Motor
4	4967	11.45-12.00	Adhi Kusmantoro	Enhancement DC Microgrid Power Stability With a Centralized
5	6910	13.45-14.00	Yanuar Zulardiansyah Arief, Hendri Masdi, Nur Izziani Roslan, Mohd Hafiez Izzwan Saad, Hamzah Eteruddin and Rosyid Ridlo Al Hakim	Investigation on Various Faults of 500 kV Transmission Line Design in Sarawak, Malaysia Using Power Systems Computer Aided Design
6	7243	14.00-14.15	Unit Three Kartini, Hariyati Hariyati, Widi Aribowo and Ayusta Lukita Wardani	Development Hybrid Model Deep Learning Neural Network (DL-NN) For Probabilistic Forecasting Solar Irradiance on Solar Cells To Improve Economics Value Added

7	7547	14.15-14.30	Ilham A.E. Zaeni, Wahyu Primadi, Dessy Rif'A Anzani and Anik Nur Handayani	Detection of the Imbalance Step Length using the Decision Tree
8	8559	14.30-14.45	Yanuar Zulardiansyah Arief, Hendri Masdi, Kelvin Juing Anak Tinggom, Aulia, Irza Sukmana and Rosyid Ridlo Al Hakim	Simulation of Water Tree Defect on Different Type of XLPE Underground Power Cable Using Finite Element Analysis
9	9022	14.45-15.00	Widi Aribowo, Reza Rahmadian, Mahendra Widyartono, Aditya Chandra Hermawan, Ayusta Lukita Wardani and Unit Three Kartini	Tasmanian Devil Optimization For Economic Load Dispatch
10	9597	15.00-15.15	Nibras Syarif Ramadhan, Indra Ferdiansyah and Era Purwanto	Voltage Booster for Optimizing Scalar Control Methods on Single Passenger Electric Vehicles
11	9806	15.15-15.30	Jamiu Omotayo Oladigbolu, Mustafa M.A. Seedahmed, Rifqi Firmansyah Muktiadji and Amir A. Imam	Optimal Design and Viability Assessment of a Stand-alone Hybrid Power System for the Electrification of a Grid-unconnected Location in Saudi Arabia

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2	4772	11.15-11.30	Hakkun Elmunsyah, Wahyu Nur Hidayat, Hary Suswanto, Khoirudin Asfani, Muhammad Akhsan Hakiki and Kusumadyahdewi Kusumadyahdewi	Development of Mobile Learning Applications With Augmented Reality to Build VHS Students' Critical Thinking
3	5137	11.30-11.45	Banni Satria Andoko, Putra Prima Arhandi, Faiz Ushbah Mubarok, Mungki Astiningrum, Tsukasa Hirashima and Muhammad Fachry Najib	Constructing Toulmin's Logical Structure Through Viat-map Application For Reading Comprehension of EFL Students
4	5716	11.45-12.00	Arda Editya, Neny Kurniati and Angga Lisdiyanto	Optimalization Jaro Winkler Algorithm Using Fuzzy Logic to Evaluate Essay Questions in E-Learning System Based Microserver
5	5985	13.45-14.00	Mohammad Idhom, Munoto Munoto, I Gusti Putu Asto Buditjahjanto and Muchlas Samani	Performance Evaluation of Automated Essay Scoring Online System for Competency Assessment of Community Academy
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8	8415	14.30-14.45	Lusia Rakhmawati, Achmad Imam Agung and Miftahur Rohman	Virtual Laboratory-Based Student Worksheets Development for Computational Thinking Practices
9	9697	14.45-15.00	Subuh Haryudo, Euis Ismayati and Farid Baskoro	Development of Training Kit for Solar Cell Off-Grid System based on Project-based Learning to improve learning outcomes
10	9816	15.00-15.15	Sunarti Sunarti and Irawan Dwiwahyono	Optimizing the Certainty Factor on K-Nearest Neighbor to Determine the Learning Model during the Pandemic

Simulation of Water Tree Defect on Different Type of XLPE Underground Power Cable Using Finite Element Analysis

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***Abstract*—This paper deals with investigation on different type of cross-linked polyethylene (XLPE) underground power cable due to water tree defects. Electric field distribution and its strength were observed by finite element analysis (FEA) technique. The defect types are vented water tree and bow-tie water tree which are mainly found in polymeric cables. Each defect sizes were modelled and simulated, then the position of the defects is varying with regard to XLPE insulation and cable conductor. The rated voltage was varied according to the cable type in order to observe the electric field distribution performances. The design and modelling of the cable in this work will be conforming to the IEC 60502-2 Standard. The results revealed that the vented water tree defect gives the highest value of electric field intensity compared to bow-tie water tree defect.**

Keywords*—*XLPE underground cable, water tree defect, electric field distribution, finite element analysis, vented water tree, bow-tie water tree.

I. Introduction

XLPE cable are widely been used in power system. There are advantages and disadvantages using this type of insulation. Degradation in XLPE insulation is result in partial discharges that have been initiate at the degradation location. Partial discharge can be defined as small or partially electrical discharges caused by massive electrical stress modification due to the fault circumstances or some defects [1]. The discharge occurring internally in the insulation material or at its interface causes an abnormal strong and erratic electric field, which is commonly caused by void, deformities, cavities, solid metallic residues due to manufacturing processes or water trees [2]. As a pre-breakdown phenomenon, the situation like environmental temperature, mechanical stress, voltage frequency and electric field strength at the insulator are influence in the formation of electrical treeing in the polyethylene material like in power cables [2].

Defect in XLPE cable is accidentally happen during the manufacturing process. The unsteady extrusion process is result in present of defect such as void and water tree defects. In addition, there also have metallic solid residues which might be mixed up with insulation material. This defect is dangerous toward the cable life span as it can be shortened because it is not work as its normal condition.

Water trees is the one of the aging factors in XLPE power cables. In the manufacturing industries, building and installation process, some microscopic defects are ultimately formed in the insulation of XLPE power cables. The cable will significantly loss its breakdown strength is the length of water tree is 60% to 80% to the insulation thickness [3-4]. In this research work, water tree defect is categorized in two types which are vented water tree and bow-tie water tree, respectively.

Vented water trees are the growth of the tree's trunk of isolating bulk from the screens on the conductor and is vented to the insulation surface. The vented is look like a needle. Moreover, there are also branches that most of the time are away from the insulation surface, where the direction of the electric field was followed [5]. The ventilated tree is more significant in terms of service aging than that of the bow - tie water tree, and the ventilated tree is more difficult to study than the bow - tie water tree [6]. In addition, vented water tree has low intensity and propagation rate compared with bow - tie water tree. This water tree defect is often occurred at the surface of the insulation.

Whereas, Bow - tie water trees are the most inherently dangerous material that grows from a void to the conducting screens. In dielectric isolation, the arch tree can grow symmetrically out of the electrode. In addition, the bow - tie water tree defect consists of divergent straight branches that radiate from a central point in opposite directions. It can also be defined as initiating in the insulation volume and can grow along the electric field lines in opposite directions [7]. The growth of bow – tie water trees is usually reduced at a certain time and the total length is limited so that this type of water tree is seldom the source of the cable break. The length of the bow - tie water trees depends on the size of the site which contains the impurities [6].

The main objective of this research work is to investigate the electric field distribution and its strength in the XLPE power cable insulation by manipulating the size and position of the water tree defect with different voltage rating.

II. Methodology

A. Simulation Procedure

Finite Element Analysis (FEA) is a numerical method to get a precise solution of problems with multi area of interest especially physic and mathematical problems. This FEA transforms the designed model into a mesh where it will divide the design in many boundaries. Then, it will calculate the value or problem at every boundary of the model in order to get very fine result. The solution for the analysis method generally using partial differential equation. To simulate the defect on the medium voltage of XLPE insulation cable by determining the electric field distribution, the COMSOL™ Multiphysics software was employed. In this software, there are four major modules that able to solve engineering problems where it is not specifically to electrical engineering field only. In this work, Electromagnetic Modules are selected as it is having AC/DC module in it which more focusing to electrical engineering design. The COMSOL Multiphysics in this study is version 5.3 for educational purposes [8].

B. Modeling of water tree defects on XLPE power cable

The objective for this simulation is to observe the effect of the electric field potential toward the XLPE cable insulation including the selected type of defect that will be placed on the insulation material. Two-dimension (2D) models are used for the simulation of the electric field. This is because the study is observing the electric field distribution and electrical potential on the XLPE material which is more reliable and appropriate to design and show the desired result. Electric field lines are perpendicular to equipotential lines and directed from the surface of the conductor to the outer sheath of the insulator.

The work was performed using medium voltage single core XLPE cable insulation conforming IEC 60502-2 Standard. This standard deals with to the medium voltage level cable. There are few maximum voltage ratings that stated in this standard, namely 7.2, 12, 18, 24, and 36 kV, respectively. The dimensional is varied according to their voltage rating and the diameter of the conductor. The higher the voltage, the thicker the insulation cable. Within this standard, one particular voltage rating is divided into many dimensional parameters according to the cable nominal cross section area (mm^2). So that, to make the standardization, the work only studied XLPE cable with 240 mm^2 cross section area at all voltage rating that will be observed. Table 1 shows the dimensional parameters that will be used in this work.

The model geometry used in the simulation is a circle for cable, while vented water tree and bow-tie water tree is a 10° of arch with radius is vary, namely 10, 20, 30, 40, 50, and 60 μm, respectively. The material that injected in this defect was distilled water. The modeling of the cable in the simulation can be seen in the Fig. 1 where r1 is the measurement of the conductor and the r2 is the measurement for insulator, respectively. Fig. 2 and 3 show the modeling of vented and bow-tie water tree in the simulation work, respectively. The parameters for the model including the water tree defects are summarized in Table 2.

TABLE I. XLPE Single-Core Cable Geometric Parameters [9-10]

Component	Rate voltage (Uo) / Maximum Rated Voltage (Um)				
	6/7.2kV	11/12kV	15/18kV	22/24kV	33/36kV
	Dimension Parameters (mm)				
Conductor Diameter	18.73				
Inner Sheath Thickness	1.70	1.80	1.90	2.00	2.20
Insulation Diameter	24.93	26.53	28.73	30.73	36.73
Outer Sheath Thickness	3.20	3.30	3.50	3.70	4.10
Earthing Screen Thickness	0.80				
Bedding Thickness	1.30				
Armour Wire Diameter	2.50				
Overall Diameter	71.00	75.00	81.00	87.00	101.00

TABLE II. Parameters of Tested Materials [1, 2, 11]

Material	Relative Permittivity, ε_r	Conductivity (S/m)
Cross-linked polyethylene	2.3	1×10^{-15}
Air	1	0
Distilled water	80	5.5×10^{-6}
Copper	1	58.8×10^{6}

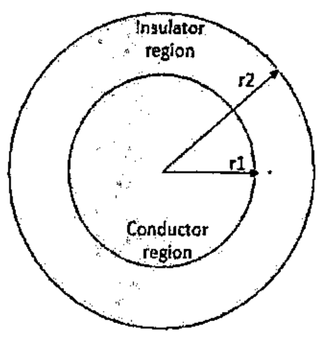


Fig. 1. Modeling of XLPE power cable conductor and its insulation.

Moreover, at each maximum rated voltage being simulate, the position of the defect will be located different positions depending on the real situation of occurrences. The positions of the defect that being observe in this work are close to conductor, middle of the insulator and far from the conductor where it is actually place at 25%, 50% and 75% respectively on the insulator thickness started from the conductor surface. Nevertheless, vented water tree defect is located at the surface of the conductor and the surface of the insulator. The distance/position for these defect are tabulated in Table 3 and 4, respectively.

Electrostatic model is used in this simulation as it emphasizes the Poisson equation to calculate the cable model. Poisson's equation is a partial differential equation method which derived from Gauss's law and Coulomb's law. It is a second-order partial differential equation used for solving problems, such as finding the electric potential for a given charge distribution or modeling gravitational fields. This concept is commonly used in the fields of electrostatics, mechanical engineering as well astheoretical physics.

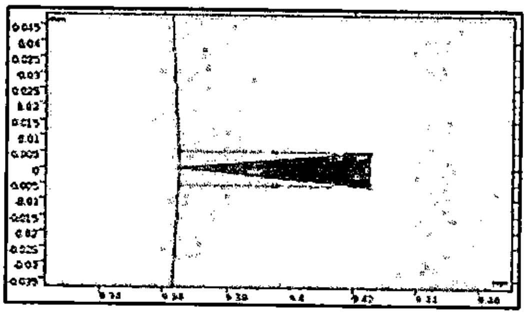


Fig. 2. Modeling of vented water tree defect.

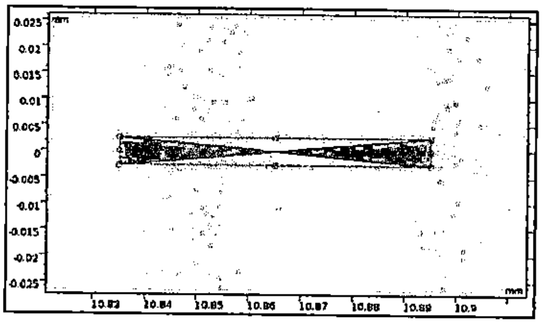


Fig. 3. Modeling of bow-tie water tree defect.

TABLE III. DISTANCE OF VENTED WATER TREE DEFECT WITH RESPECT TO THE CENTER OF THE CONDUCTOR

Position	Maximum Rated Voltage of XLPE Cable (kV)				
	7.2	12	18	24	36
	Distance of vented water tree defects from the centre of the conductor (mm)				
Close to conductor	9.365				
Far from conductor	12.465	13.265	14.465	15.365	18.365

TABLE IV. DISTANCE OF BOW-TIE WATER TREE DEFECT WITH RESPECT TO THE CENTER OF THE CONDUCTOR

Position	Maximum Rated Voltage (kV)				
	7.2	12	18	24	36
	Distance of bow-tie water tree defects from the centre of the conductor (mm)				
Close to conductor	10.140	10.340	10.615	10.865	11.615
Middle of the insulator	10.915	11.315	11.865	12.365	13.865
Far from conductor	11.690	12.290	13.115	13.865	16.115

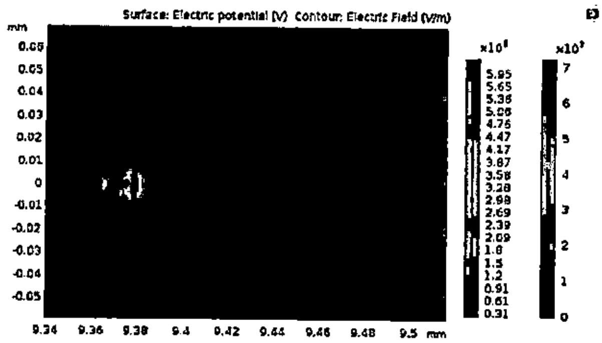
III. RESULT AND DISCUSSION

A. Water Tree Defects Close to The Conductor

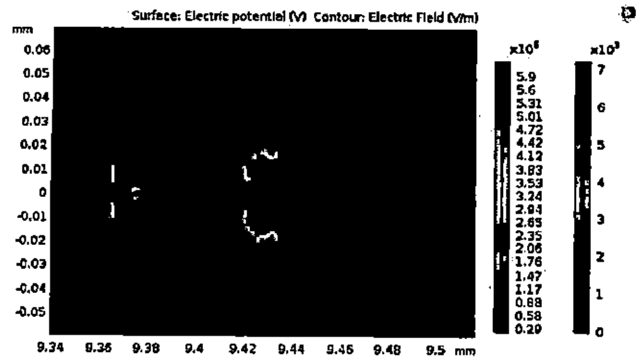
A.1. Vented Water Tree Defect

Fig. 4 shows simulation results for electric field distribution of vented water tree defect where the defect position/location close to the conductor of 7.2 kV XLPE power cable type. While, Fig. 5 shows simulation results for electric field potential of vented water-tree defect at close to the conductor for 7.2 kV XLPE power cable type. As can be seen from those figures, it is found that the value of electric field intensity distribution according to it rated voltage during observing the vented water tree defect located close to the conductor with radius of 10 and 60μm, respectively. The electric field intensity gave the higher value at the small size of the defect in each cable type. The small size of the defect tends to create the very sharp edge compare to the larger defect. Therefore, the electric field is varying due to the shape of the vented water tree defect simulated in the software.

Fig. 6 shows simulation results for electric field potential maximum values of vented water tree defect at close to the conductor for all XLPE cable type. Based on the figure 4.8 below, the result shows the same characteristic to the vented water tree defect place closer to the conductor. It showed that the 36 kV cable give the highest electric field intensity while the 7.2 kV is the lowest electric field intensity in simulation for the air void which place closer to the conductor. This is because the electric potential at the 36 kV is the highest among the rest of the cable when the defect is in the same position. Thus, there are high electric field strength near to the conductor which will elevate greatly when there is defect occur.

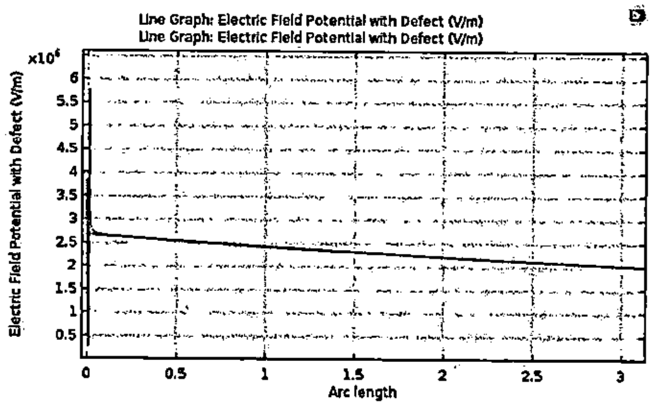


(a) Defect radius: 10μm

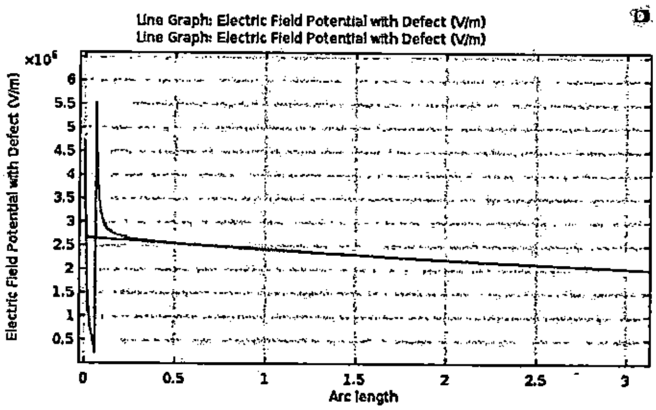


(b) Defect radius: 60μm

Fig. 4. Simulation results for electric field distribution of vented water tree defect at close to the conductor of 7.2 kV XLPE power cable type.



(a) Defect radius: 10μm



(b) Defect radius: 60μm

Fig. 5. Simulation results for electric field potential of vented water-tree defect at close to the conductor of 7.2 kV XLPE power cable type.

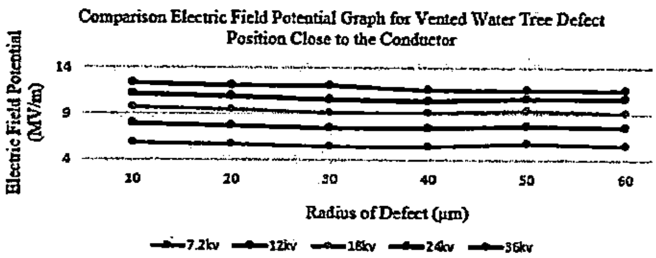


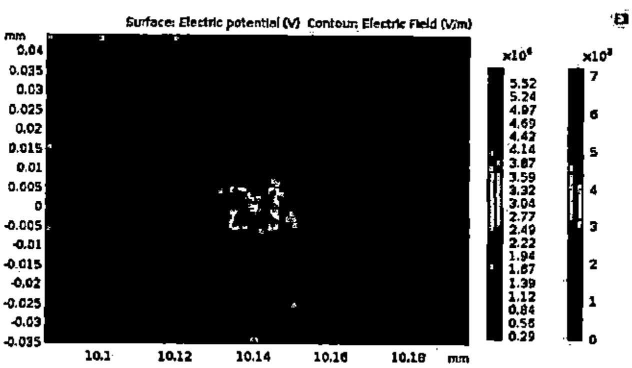
Fig. 6. Simulation results for electric field potential maximum values of vented water tree defect at close to the conductor for all XLPE cable type.

A.2. Bow-Tie Water Tree Defect

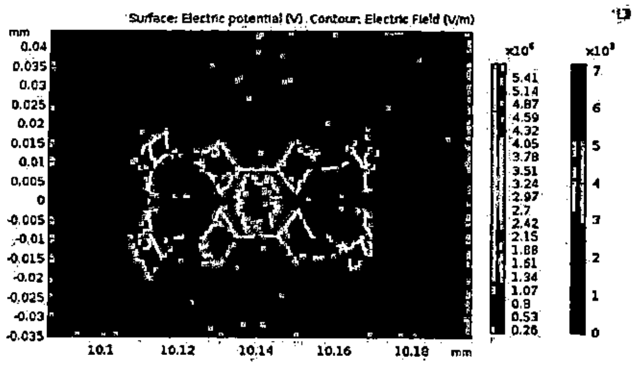
Fig. 7 shows simulation results for electric field distribution of bow-tie water tree defect where the defect position/location close to the conductor of 7.2 kV XLPE power cable type. While, Fig. 8 shows simulation results for electric field potential of bow-tie water-tree defect at close to the conductor for 7.2 kV XLPE cable type. Then for simulation results of all XLPE power cable type is summarized in Fig. 9.

As can be seen from Fig. 9, the maximum values of electric field intensity are according to their rated voltage. The higher rated voltage gives higher value of electric field potential. The bow-tie water tree defect makes the electric field become distorted and tends to concentrate to the point at which the defect occurred, then resulting in high electrical stress. The higher electrical stress can make the electric field intensity to increase. The amount of electrical stress depends on the electric potential distribution on the insulation. It is found that the electric potential at the defect is high as it is close to the conductor.

Moreover, it showed that the 36 kV XLPE cable type has the highest electric field intensity while the 7.2 kV is the lowest electric field intensity in simulation for the bow-tie water tree which place close to the conductor. The 36 kV cable does not increase to much like the increases between 24 kV and 18 kV cable types. This is because the 36 kV cable has the thicker insulator where the electric potential distribution can have made further decrement toward the insulator surface.

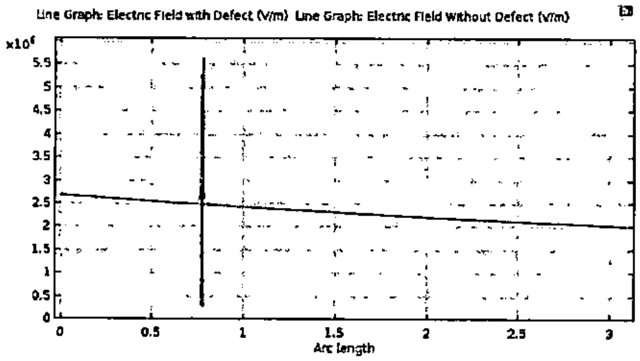


(a) Defect radius: 10μm

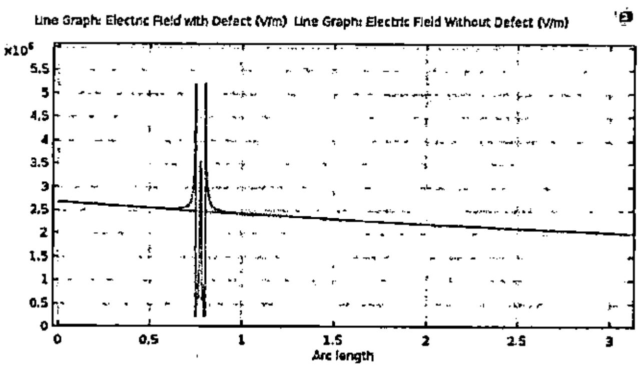


(b) Defect radius: 60µm

Fig. 7. Simulation results for electric field distribution of bow-tie water tree defect at close to the conductor of 7.2 kV XLPE power cable type.



(a) Defect radius: 10µm



(b) Defect radius: 60µm

Fig. 8. Simulation results for electric field potential of bow-tie water tree defect at close to the conductor of 7.2 kV XLPE power cable type.

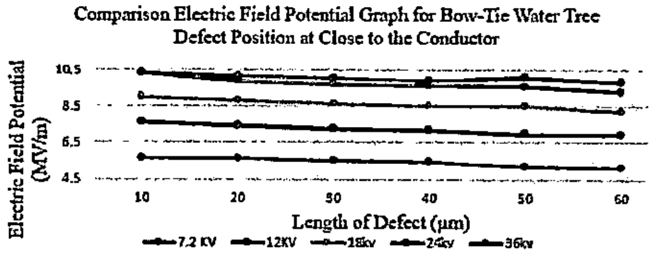


Fig. 9. Simulation results for electric field potential of bow-tie water tree defect at close to the conductor for all XLPE cable type.

B. Water Tree Defects Far from The Conductor

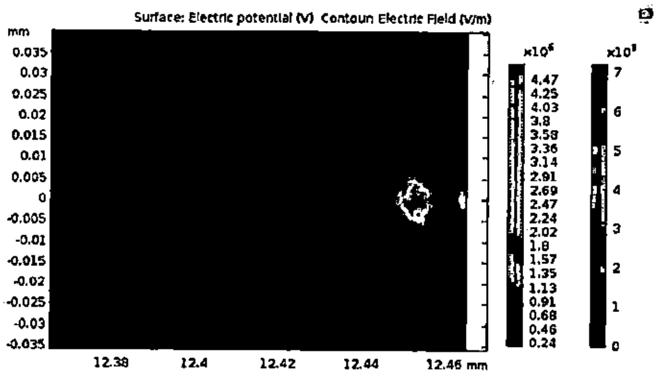
B.1. Vented Water Tree

Fig. 10 shows simulation results for electric field distribution of vented water tree defect where the defect position/location is far from conductor of 7.2 kV XLPE power cable type. While, Fig. 11 shows simulation results for electric field potential of vented water-tree defect at far from conductor of 7.2 kV XLPE power cable type. Then for simulation results of all XLPE power cable type is summarized in Fig. 12.

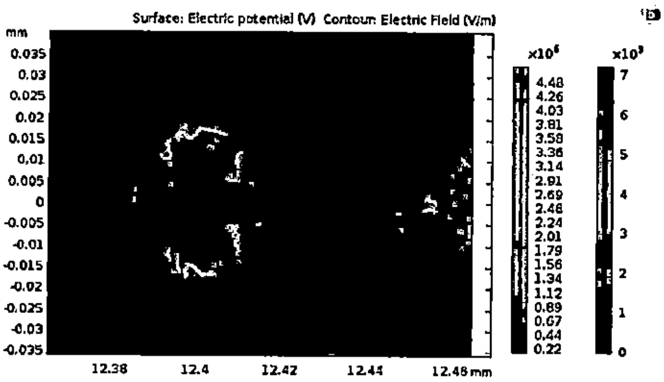
As can be seen from Fig. 12, the values of electric field intensity are according to their rated voltage. The higher rated voltage gives higher value of electric field potential. The electric field intensity value is decreasing compared to the value at which the defect is placed closer to the conductor. This is because the water tree defects are locating near to the insulator surface which it almost reaches to the 0V or grounded. Thus, the electric field strength or intensity generated is lower compared to the electric field at close to the conductor.

Moreover, it showed that the 24 kV XLPE cable type gives the highest electric field intensity while the 7.2 kV cable type has the lowest electric field intensity in simulation for vented water tree defect far from the conductor. Unlike the vented water tree defect which placed close to the conductor, the 36 kV XLPE cable type has lower value compared to 24 kV cable type for electric field intensity even though it has more rated voltage. This is because 36 kV has the thickest insulator which able to decrease the electric potential greatly compared to the other cables. It is also found that the electric field intensity in 18 kV cable type is almost same to the 36 kV cable. Sometimes, it has higher electric field strength compared to 36 kV cable.

The vented water tree defect which exist in the XLPE cable might cause a very high electric field strength. Due to this defect, the high electric field strength occurs at the edge of the defect. Meanwhile, inside the vented water defect show that the electric field intensity is decrease drastically. This can be seen at the electric field intensity graph in each vented water tree simulation result. This is because, the relative permittivity inside the vented water tree is higher compare to insulator material. The relative permittivity use inside the defect is 80 which represent the tap water. So, there are low discharge occur is inside the defect. Nevertheless, the electric field are convergence toward the edge of the vented water tree where it is model like needle shape. The sharp edge experiencing the higher electric field stress. This high electrical stress will create the high temperature due to the friction from high discharge on the XLPE material. The defect will be elongated longitudinally to the insulator surface due to chemical bond breakdown and partial discharge which resulted in erosion and total electrical breakdown.

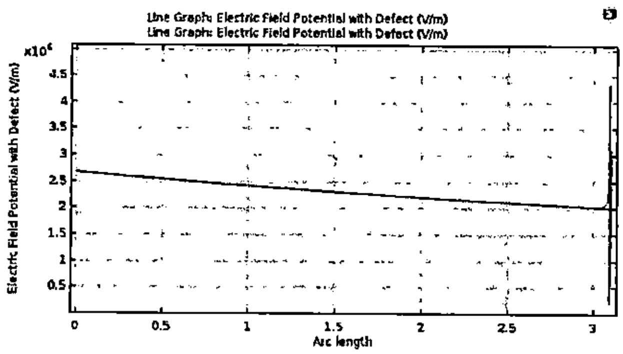


(a) Defect radius: 10μm

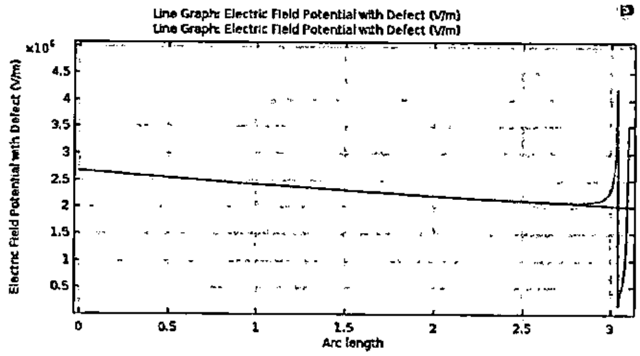


(b) Defect radius: 60μm

Fig. 10. Simulation results for electric field distribution of vented water tree defect far from the conductor of 7.2 kV XLPE cable.



(a) Defect radius: 10μm



(b) Defect radius: 60μm

Fig. 11. Simulation results for electric field potential of vented water tree defect far from the conductor of 7.2 kV XLPE cable.

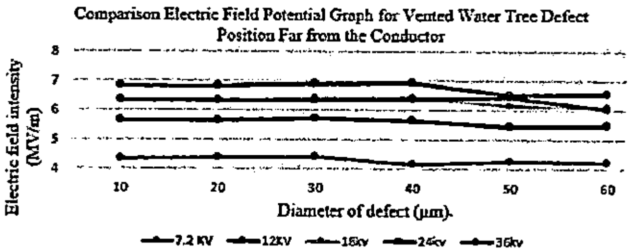


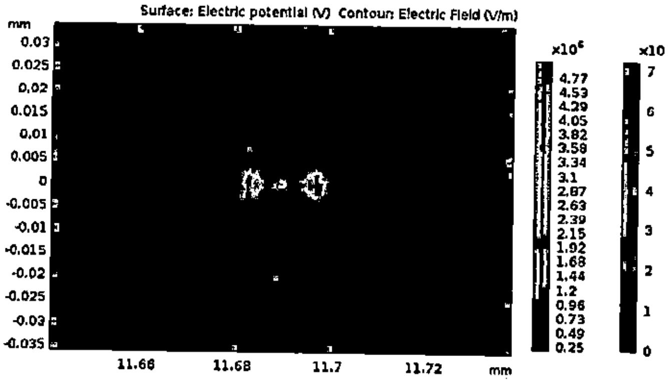
Fig. 12. Simulation results for electric field potential of vented water-tree defect far from the conductor for all XLPE cable type.

B.2. Bow-Tie Water Tree Defect

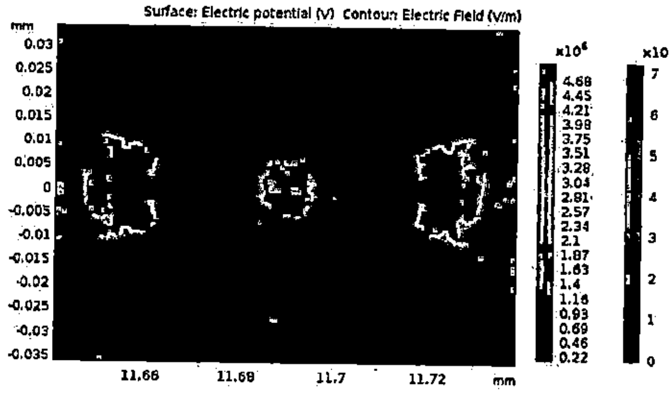
Fig. 13 shows simulation results for electric field distribution of bow-tie water tree defect where the defect position/location is far from the conductor of 7.2 kV XLPE power cable type. While, Fig. 14 shows simulation results for electric field potential of bow-tie water tree defect at close to the conductor for 7.2 kV XLPE cable type. Then for simulation results of all XLPE power cable type is summarized in Fig. 15.

As can be seen from Fig. 15, similar like the previous results, the maximum values of electric field intensity are according to their rated voltage. The higher rated voltage gives higher value of electric field potential. The electric field intensity value is decreasing compared to the value for defect close to the conductor. This is because the bow-tie water tree defect is placed near at insulator surface which it almost reaches to electrical grounded potential. Thus, the electric field strength or intensity generated is lower compared to the electric field at close to the conductor.

Interestingly, it is found that the 24 kV XLPE cable type has the highest electric field intensity, while the 7.2 kV has the lowest electric field intensity in simulation for defect far from conductor. The 36 kV cable also lower than 24 kV cable for electric field intensity even it has more rated voltage. This is because 36 kV cable type has the thickest insulator which able to decrease the electric field potential greatly compared to the other cable types.

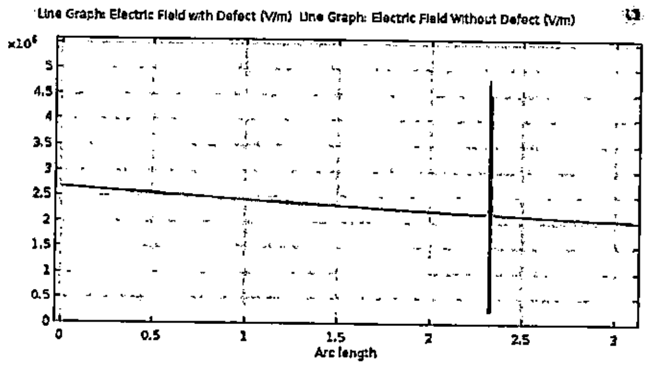


(a) Defect radius: 10µm

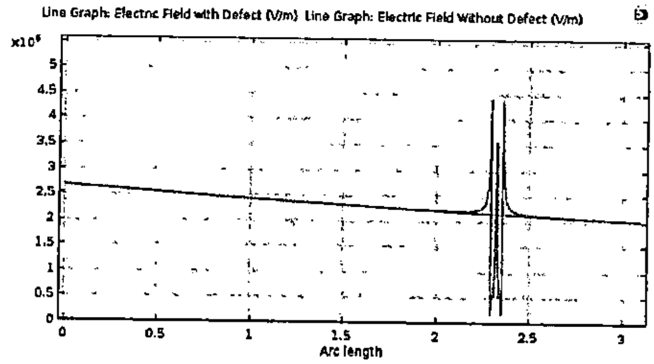


(b) Defect radius: 60µm

Fig. 13. Simulation results for electric field distribution of bow-tie water tree defect far from the conductor of 7.2 kV XLPE power cable type.



(a) Defect radius: 10µm



(b) Defect radius: 60µm

Fig. 14. Simulation results for electric field potential of bow-tie water tree defect far from the conductor of 7.2 kV XLPE power cable type.

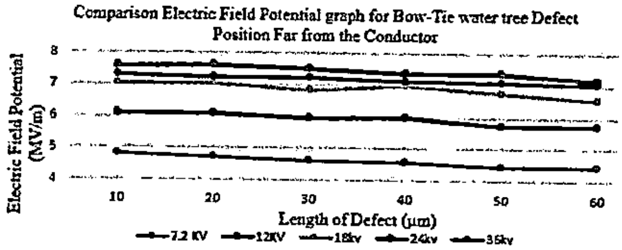


Fig. 15. Simulation results for electric field potential of bow-tie water tree defect far from the conductor for all XLPE power cable type.

As overall, the simulation results showed that the electric field intensity or strength is decreased when the size of the simulated defect is increasing. The plotted line graph which showed the electric field intensity across the defect has given W-shape graph where the among three high electric strength value indicate the end to end defect surface and the center of the defect. This shows that the electrical stress occurs at these three points. This is because the electric field are deflected toward the end to end of defect surface due to the higher relative permittivity inside the defect compared to the XLPE material which are 80 to 2.3 ratio. Thus, there will be no high discharge occurs inside the bow-tie water tree defect unlike in the air void defect [12-14]. That is why the electric field intensity is drop drastically which it is almost to 0 MV/v below. Due to the sharp edge at end to end surface, the electric field are forced to deflect sharply which result to very high stress toward the electric field line. This makes at these two points is higher in field strength compared to the one at the center of the bow-tie water tree.

Besides, the electric field is become lower when the size of the bow-tie tree defect is greater. This is because the electric field are concentrated to the very tiny defect that have higher relative permittivity compared to insulator which cause the electric field being compact.

IV. CONCLUSION

In this research work, the investigation of water tree on XLPE underground cable using FEA have successfully conducted. The water tree defects have been simulated in the work with different locations on the insulator and energized by 5 (five) different level in medium voltage rating.

The simulation results revealed that the electric field intensity or strength is decreased when the size of the simulated defect is increasing. The plotted line graph which showed the electric field intensity across the defect has given W-shape graph where the among three high electric strength value indicate the end to end defect surface and the center of the defect. It is found that the vented water tree defect gives the highest value of electric field intensity compared to bow-tie water tree defect.

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