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ТЕСЛИНИ ИНОВАЦИОНИ ДАНИ - ТИД

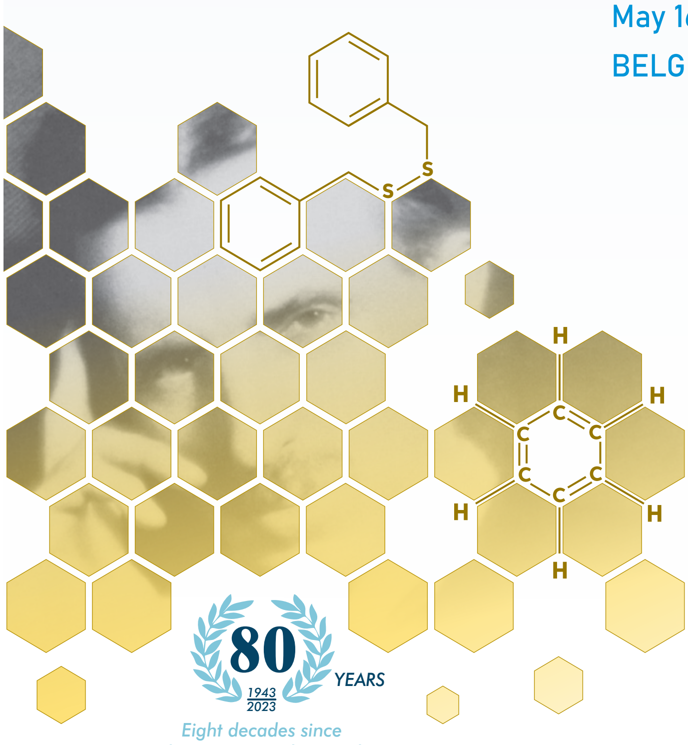
16 - 18. 05. 2023. године

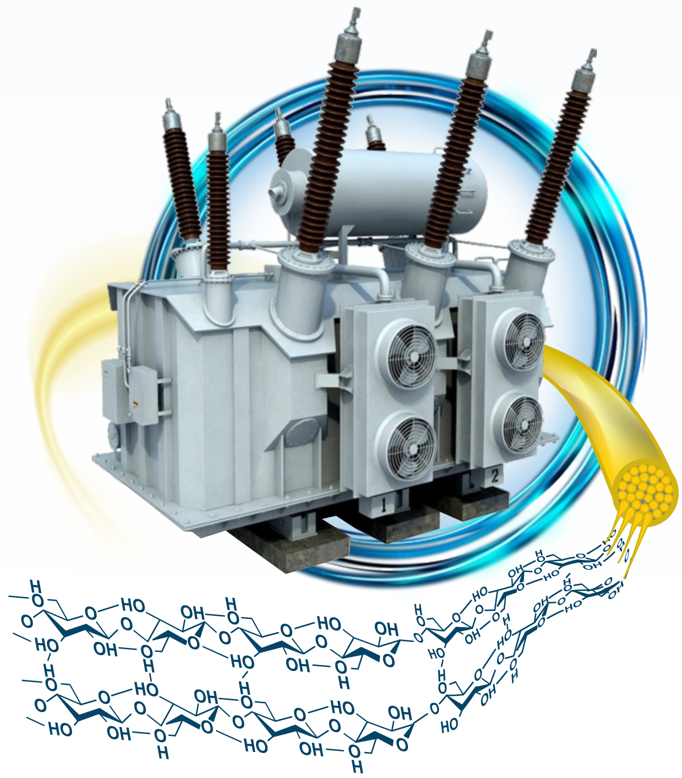
Београд, Србија

TESLA INNOVATION DAYS - TID

May 16th to May 18th 2023

BELGRADE, SERBIA





BOOK OF ABSTRACTS

Belgrade, 2023.

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ELECTRICAL ENGINEERING INSTITUTE NIKOLA TESLA Joint Stock Company BELGRADE

Address: Koste Glavinića 8a, 11040 Belgrade, Serbia, PO Box 139

Switchboard: +381 (0)11 39-52-000

Fax: +381 (0)11 36-90-823

Direct: +381 (0)11 36-90-487

info@ieent.org

https://www.ieent.org/

EDITOR

Dr. Jelena Lukić

Branka Đurić

TECHNICAL SUPPORT & COVER DESIGN

Marjan Stojković

PRINTED BY

GPC – Grafičko poslovni centar d.o.o. Beograd

Printed in 20 copies

CIP - Каталогизација у публикацији
Народна библиотека Србије, Београд

621.314.2(048)
621.315.615(048)

TESLA Innovation Days (2023 ; Beograd)
Book of Abstracts / Теслини иновациони дани, ТИД, 16-18. 05. 2023. године, Београд, Србија ; [у организацији] Електротехнички институт Никола Тесла, Београд = Tesla Innovation Days, TID, May 16th to May 18th 2023, Belgrade, Serbia ; [organized by] Electrical Engineering Institute Nikola Tesla, Belgrade ; [editor Jelena Lukić, Branka Đurić]. - Belgrade : Electrical Engineering Institute Nikola Tesla Joint Stock Company, 2023 (Beograd : GPC - Grafičko poslovni centar). - 29 str. : ilustr. ; 30 cm

Tiraž 20. - Bibliografija uz pojedine apstrakte.

ISBN 978-86-83349-18-0

а) Трансформатори -- Апстракти б) Уља, трансформаторска -- Апстракти

COBISS.SR-ID 118484745

TESLA INNOVATION DAYS – TID 2023

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7. Dr. Vladimir Šiljkut, research associate, Scientific field: electrical engineering and power engineering, advisor to the general manager of JSC EPS, Serbia;
8. Dr. Radomir Todorović, Director of the EEO maintenance sector at the Technical Center in ODS, Scientific field: electrical engineering / power switches, current scientific and research engagement: co-author in numerous papers.

ORGANIZATION

Dr. Jelena Lukić, Branka Đurić, Vladimir Polužanski, Marjan Stojković, Milica Radak, Marina Ivanković

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SHORT ABSTRACTS

Advanced oil testing techniques in corrosive sulphur risk assessment & innovative technology in PT risk mitigation and life extension

Dr. Jelena Lukić, Electrical Engineering Institute Nikola Tesla, Serbia

Jelena Janković, Electrical Engineering Institute Nikola Tesla, Serbia

Demands over last few decades on high quality and longevity of insulating materials for power transformers (PT) and sustainable and resilient electricity supply, together with requests to decrease carbon footprints and improve environmental impact, have caused extensive changes in technologies of materials production and their performance. Problem with sulphur corrosion in mineral oils appeared in several forms over the last two decades, causing PT failures. At first, copper corrosion was observed, but later on, silver corrosion even more detrimental for PT failure. State of the art mitigation techniques have been partially successful and in some part even caused failures of PT. Conventional technologies, oil regeneration with reactivating adsorbents can be the root cause of two serious hazards: air pollution if treatment of non PCB free oils is done and creation of elemental sulphur, unwanted contaminant causing failure of PT. Conventional insulating liquids re-refining and recycling are challenging in terms of application of green technologies to fulfill demands and EU directives (Green Deal) to reduce carbon footprints for green energy. Application of biodegradable natural ester insulating liquids is welcomed from the environmental point of view, but also its application faces a number of challenges in relation to the application and sustainability. This presentation attempts to highlight one of the most serious problems encountered with conventional mineral insulating oils, sulphur corrosion endangering the operation of PT. It will adress apporoches in copper and silver corrosion risk assessment and application of effective mitigation techniques. With the aim to improve silver corrosion risk assessment, new testing technique has been developed in the Institute which provides upgrading of the existing standards, DIN 51353 and ASTM D 1275. Contamination of PT with elemental sulphur, as main

drawback of the application of reactivating adsorbent technology applied in oil regeneration and removal of corrosive sulphur will be addressed, as well as problem of air pollution as negative side effect of this technology. Main environmental problem with application of oil regeneration with reactivating adsorbents is high temperature oil burning that can create toxic emissions from the mobile plants, if the oil which has undergone oil regeneration contains even minute concentrations of PCB (from 5 to 50 mg/kg). This process than induce negative impact on the environment and cause operational risk of failure due to elemental sulphur formation. Solution to this problem is application of low temperature environmentally friendly oil treatment technology for complete oil re-refining/recycling, removal of all corrosive sulphur species, PCB and oil ageing products (3 PINT). Technology is developed in the Institute and it is designed for on-site and off-site oil re-refining, removal of PCB, DBDS and other reactive disulphides below 2 ppm and elemental sulphur below 0.5 ppm, having refined oil properties restored to as new condition.

Jelena Lukić, PhD in Chemical Engineering has been employed at Electrical Engineering Institute Nikola Tesla, Belgrade, Serbia since 1996. She holds the position of head of a specialized laboratory for oil and paper insulation testing, accredited according to ISO 17025. Her field of expertise is insulating oil and paper analyses and power transformers condition assessment, insulating oil and cellulose ageing, know-how in oil treatment processes for the removal of corrosive sulfur and PCB and holds two registered patents in this field. She has published 92 research and technical papers and has been a project leader of more than 20 research projects in the topics mentioned above. Jelena has been a member in more than 20 CIGRE SC D1, SC A2 and IEC TC 10 WG's over the past two decades. She is currently convener of CIGRE WG D1.76: Tests for the verification of quality and ageing performance of cellulose insulation for power transformers. Jelena Lukic is a delegate of the Serbian National Committee in International Electro-technical Committee Technical Committee 10 (IEC TC 10) – Fluids for Electro-technical Applications, Serbia NC Representative in CIGRE SC A2-Transformers and IEC TC 10 Liaison Co-officer of CIGRE SC A2.

Jelena Janković, M.Sc. in chemical engineering, has been working in Electrical Engineering Institute Nikola Tesla from 2009. She works in specialized laboratory for mineral insulating oil and paper testing, in a position of associate research engineer and deputy head of the specialized laboratory. Her main field of work is oil and paper analysis, power transformers condition assessment and research activities of oil re-refining and reclamation process in order to remove corrosive sulfur compounds and ageing products from the mineral oils. She is one of the inventors of National registered patent 2019, for removal of sulphur compounds corrosive to silver from mineral transformer oils. Jelena Janković is a member of IEC TC 10 MT 43 for Revision of IEC 60666 - Detection and determination of specified additives in mineral insulating oils. She is a member of Serbian National Committee CIGRE SC A2 – Transformers and a member of Technical Committee KS N010 - Fluids for electrotechnical applications of Institute for Standardization of Serbia. She is pursuing a PhD at the Faculty of Technology and Metallurgy, University of Belgrade.

On Alternative Liquids in Power Transformers: Approval & Application

Dejan Vuković, Hitachi Energy, Bad Honnef, Germany

Ahmed Gamil, Hitachi Energy, Bad Honnef, Germany

The use of mineral oil in transformer technology has proved over decades the reliability of performance regarding two main functions, dielectric and cooling. With globally increased sustainability awareness, it became clear that transformer technology can be improved using recyclable materials and applying alternative liquids, which are biodegradable, recyclable and environmentally safe.

Before starting to use alternative liquids in power transformers, either by retro-filling of existing units or making new design, certain investigations on the dielectric, thermal and other properties of these liquids need to be done. Different transformer products may have different application requirements and this has to be reflected into liquid properties. Often, existing mineral oil based design rules need to be changed and adopted to liquid properties. The practice has showed that alternative insulating liquids often have different dielectric performance, more particularly the discharge behavior (initiation and propagation) is different. Moreover, the cooling performance of the liquid in combination with the designed cooling system must be checked to ensure no exceeding of winding hotspot and liquid top temperature limitations. Also, during the production process, the filling process and treatment plant need to be adapted to manage the new liquid.

Furthermore, there are other tests related to the material used and transformer components with respect to operation of transformers and their expected lifetime. Compatibility and aging test are settled well in international standards for mineral oil, while there is not yet a clear guidance when using alternative liquids. The chemical and physical differences between mineral oil and alternative liquids lead to investigate if the current rule for aging and compatibility tests is suitable to approve the new liquid for transformer applications.

There is clear need to further develop liquid test methods in order to cover all aspects of transformer requirements, having in mind also some liquid properties that have not been in focus for mineral oil application. The biggest challenge is the time consumed during performance verification and the decision for application, while the market is receiving continuously new liquids promising lower environmental impact. This contribution sets the focus on this challenge in how to gain the advantages and avoid disadvantages.

Dejan Vuković, M.Sc. degree in Electrical Engineering, has 18 years of experience in R&D of Power Transformers. Since 2012 is a part of global R&D team at Hitachi Energy (former ABB), located in Bad Honnef, Germany and currently in a role of R&D Program Manager – Safe & Eco. Some of expertise areas are dielectric design rules for power transformers, alternative insulating liquids and test failure investigations. He is an active member of several IEC TC10 &14 and CIGRE A2 & D1 working groups as well as in VDE ETG and IEEE Transformers Committee. Author of numerous international conference & journal publications.

Ahmed Gamil received his M.Sc. degree from RWTH Aachen, Germany in 2004 (High Voltage Technology). Ahmed worked previously at University of Erlangen (FAU, EES) as scientific research assistance for the development of differential protection systems before joining SGB-SMIT Group. In 2010 he joined SGB in Regensburg with the aim of building the R&D Department from a technology and management point of view. In the last years as head of R&D, he contributed by different publications to transformer design optimization through improvements in losses, noise, thermal performance, and dielectric behaviour of power transformers including different application of alternative insulation liquids. His journey at SGB ends in Oct. 2022 to start a new one at Hitachi Energy as "Domain Expert for Alternative Liquids" from Nov. 2022. His focus is to improve testing procedure of insulation liquids for aging and compatibility and introduce an application guideline for power transformer under environmental stresses (i.e., cold climate). His novel approach to determine geometrically the average oil temperature rise (G-Approach) was one of the reasons for his nomination in "IEC Call for Experts" as a member of MT 60076-2 for the revision of IEC 60076-2-2011. Ahmed is nominated to be one of the authors of a new CIGRE Green Book for "Transformer Life Management" and elected to be the chairman of task force on “Insulation Liquid Thermal Class” in IEEE C57.154.

Dielectric Breakdown Phenomena of Conventional and 'New' Transformer Liquids

Prof. Dr. Qiang Liu, Reader in Power System Plant and Head of High Voltage Research Group, The University of Manchester, United Kingdom

The invention of power transformers in the late 19th century enabled the long-distance bulk transmission of electrical power through HVAC power networks. Although there are dry-type transformers and gas-insulated transformers, the majority of power transformers used in the power networks are liquid immersed, where liquid-solid composite insulation systems are adopted. Mineral oils, as a conventional insulating liquid option, have been widely used in power transformers for over a century. In the past decades, a variety of 'new' transformer liquids including natural and synthetic ester liquids, gas-to-liquid (GTL) oils, biodegradable hydrocarbon liquids have emerged in the market, and they all possess certain improved properties, e.g. biodegradability, fire safety, purity and so on. Knowledge of transformer insulation design has been accumulated mainly based on the experience of using mineral oils, which may not be readily appliable for these new liquids.

This lecture will first introduce the fundamental breakdown mechanisms of dielectric liquids. Streamer is a widely accepted term used to describe the pre-breakdown process in liquids. The basic characteristics of streamer in liquids will be introduced, with more details can be found in a recently published CIGRE technical brochure [1]. Dielectric breakdowns in transformer liquids can be broadly grouped into streamer initiation controlled breakdown and streamer propagation controlled breakdown. The former is dominating breakdowns under uniform field while the latter is dominating breakdowns under divergent field. Most of the previous breakdown studies have focused on either the uniform field or the divergent field. There is a lack of studies considering the moderately-uniform fields. Therefore, this lecture will then pay attention to the moderately-uniform fields and invesitagte the transition field factor boundary between the two breakdown mechanisms. Two methods are proposed to determine the transition field factor boundary [2,3]. Effects of impulse polarity and liquid type on the transition field factor boundary are discussed in detail [4].

Understanding the fundamental breakdown mechanisms can help explain some different breakdown phenomena observed in the new transformer liquids. A state-of-the-art review of lightning impulse breakdown voltage studies of ester liquids in the past decades is presented in this lecture. Comparisons of impulse breakdown voltages between ester liquids and mineral oils are statistically analysed and elaborated based on the breakdown mechanisms [5]. At the end of this lecture, results of a recent study on lightning impulse breakdown voltages of various transformer liquids using a large-scale winding coil electrode with and without paper wrapping are presented, which would provide reference to transformer insulation design using these new liquids.

[1] L. Lars et al., “Dielectric performance of insulating liquids for transformers,” TB 856 CIGRE, 2021.

[2] S. Shen, Q. Liu, and Z.D. Wang, “Effect of electric field uniformity on positive streamer and breakdown characteristics of transformer liquids,” IEEE Trans. Dielectr. Electr. Insul., vol. 26, no. 6, pp. 1814-1822, 2019.

[3] H. Yu, S. Shen, Q. Liu, and Z.D. Wang, “Effect of electric field uniformity on breakdown mechanisms of dielectric liquids under lightning impulse,” IEEE Trans. Dielectr. Electr. Insul., vol. 28, no. 4, pp. 1136-1144, 2021.

[4] H. Yu, Q. Liu, Z.D. Wang, A. Hilker, C. Krause and D. Walker, “Streamer and breakdown characteristics of transformer liquids in moderately-uniform fields under negative lightning impulse,” IEEE Trans. Dielectr. Electr. Insul., 2023. (Under review)

[5] H. Yu, Q. Liu, and Z.D. Wang, “Statistical analysis and interpretation on lightning impulse breakdown voltages of ester liquids under varying field uniformity,” High Volt., 2023. (Under review)

Dr. Qiang Liu is a Reader in power system plant and the Head of High Voltage Research Group in the Department of Electrical and Electronic Engineering at the University of Manchester. Qiang obtained a PhD degree in electrical power engineering from the University of Manchester in 2011. He is the Chairperson of CIGRE D1.01 Advisory Group on “Dielectric liquids and liquid impregnated insulation systems” and a member of several CIGRE A2/D1 working groups. Qiang is also a senior member of IEEE, a member of IEEE DEIS AdCom, and an associate editor of IET High Voltage Journal. His research focuses on dielectric liquids and their applications in high voltage equipment (power transformers, subsea cable joints) and future electric transportation (EV batteries, power electronic devices). His research topics include characterisation of advanced dielectric liquids (esters, gas-to-liquids, biodegradable hydrocarbons), discharge and breakdown mechanisms of dielectric liquids, ageing assessment of liquid-solid insulation systems, immersion cooling and thermal modelling, digital twining and asset management. He has contributed to 2 CIGRE technical brochures and published 150 research papers.

Developing algorithms to estimate transformer life: is it a maths- or a physics-based process?

Dr. Shanika Matharage, Exeter University, United Kingdom

Following the post-war economic boom, there was a surge in the number of power transformers installed globally. Factors such as high safety-margin-based design; wider adoption of international standards in design, operation, and maintenance of transformers; and relatively low loading conditions due to the use of N-1 contingency strategies have resulted in many transformers operating well beyond their intended design lifespan. This places significant pressure on asset managers who must balance the risk of costly and catastrophic failures against the benefits of maximum utilization and cost savings from avoiding unnecessary replacements. However, predicting the precise lifetime of a transformer is a challenging task, given the complexity of factors such as cyclic loading, non-uniform temperature distribution, and chemical migration that contribute to the ageing process.

Estimating the lifetime of a transformer can be approached through two schools of thought: statistical-based models and degradation-based models. Statistical models rely on information from random failures, age-related failures, and data from survived transformers to predict the lifetime of a transformer fleet [1]. On the other hand, degradation-based models focus on the continuous thermal, electrical, and chemical stresses that lead to irreversible insulation degradation. Degradation-based models can be further categorized into kinetics-based models, which use temperature and water content to predict lifetime [2], and chemical marker-based models, which use paper ageing-related chemical markers to estimate insulation lifetime [3]. However, each of these approaches has its own challenges. Statistical approaches suffer from a lack of data, kinetics-based models face difficulties in accurately estimating hot-spot temperature [4], and chemical marker-based estimations face challenges related to stability and partitioning processes [5]. This lecture addresses some of the challenges associated with transformer lifetime estimation.

[1] D. Zhou, Z.D. Wang, P. Jarman, and C. Li, "Data Requisites for Transformer Statistical Lifetime Modelling - Part II: Combination of Random and Aging-Related Failures," IEEE Transactions on Power Delivery, vol. 29, no. 1, pp. 154-160, 2014.

[2] H. Z. Ding and Z.D. Wang, "Kinetic analysis and modelling of the ageing process for Kraft paper aged in natural ester dielectric fluid," in 2006 IEEE Conference on Electrical Insulation and Dielectric Phenomena, pp. 505-508, 15-18 Oct. 2006 .

[3] S. Y. Matharage, Q. Liu, Z.D. Wang, G. Wilson, and C. Krause, "Aging assessment of synthetic ester impregnated thermally non-upgraded kraft paper through chemical markers in oil," IEEE Transactions on Dielectrics and Electrical Insulation, vol. 25, no. 2, pp. 507-515, 2018.

[4] D. Feng, Z.D. Wang, and P. Jarman, "Evaluation of Power Transformers' Effective Hot-Spot Factors by Thermal Modeling of Scrapped Units," IEEE Transactions on Power Delivery, vol. 29, no. 5, pp. 2077-2085, 2014.

[5] S. Y. Matharage, Q. Liu, Z.D. Wang, and D. Walker, "Effect of Paper Type and Water Content in Paper on the Partitioning of 2-FAL between Liquid and Paper Insulations," in 2020 IEEE International Conference on High Voltage Engineering and Application (ICHVE), pp. 1-4, 6-10 Sept. 2020.

Dr. Shanika Matharage is a Lecturer in Smart Grid at the University of Exeter. He received his BSc degree in Electrical and Electronic Engineering from the University of Peradeniya, Sri Lanka in 2011. and his PhD in Electrical Power Engineering from the University of Manchester, UK in 2017. His PhD research won the "John Neal Insulation Award" awarded by European Electrical Insulation Manufacturers Association for honouring outstanding accomplishment in the field of solid and liquid electrical insulation materials and systems. He worked as a Post Doctoral Research Associate and Experimental Officer at The University of Manchester before joining the University of Exeter in 2020.

His research activities are mostly interdisciplinary, which combine knowledge and expertise from Electrical Engineering, Chemistry, and Analytical Sciences to solve research questions or to increase understanding around high voltage equipment in the areas of novel insulating materials, ageing of insulation, condition monitoring and asset management.

He has published over 30 articles. He is currently a Task Force Leader in CIGRE working group D1.76. He was also a member of the CIGRE working group JWG A2/D1.46 that published Technical Brochure 779: Field experience with transformer solid insulation ageing markers.

Advanced transformer thermal design and thermal modeling in transformer grid operation

Prof. Dr. Zoran Radaković, University of Belgrade, School of Electrical Engineering, Serbia

Liquid Immersed Power Transformers (LIPT) are devices transferring a large amount of electric power with high efficiency. Due to high currents through the winding and the magnetic field through the core, there are considerable heat losses. The temperature of the liquid and solid insulation materials should be limited in order to avoid a sudden failure due to bubbling phenomena or accelerated insulation ageing as a result of the cumulative effect of the in-creased temperature over a longer time period.

The losses and the consequent temperature change are non-uniformly distributed over LIPT volume. The primary interest is to determine the hottest winding insulation (hot-spot) and top insulation liquid (top oil) temperatures. So far, in engineering practice simplified equa-tions with empirically determined parameters were typically used, both in thermal design stage and during transformer grid operation under variable load and cooling fluid tempera-ture. Such calculations are easy to apply, but with limited accuracy. An important issue is that the temperatures cannot be determined for new designs, for which there is no experience. Consequently, there is a need for developing more complex method, which includes the influ-ence of construction details to the distribution of insulation liquid flow and heat transfer, thus to temperature distribution.

Nowadays, finite elements computational tools are powerful and found significant place in different technical fields. In some of them, the application of such computational tools can completely solve technical problems, without too big computational resources and computa-tional time, and without much convergence problems. The situation gets more complicated when two physics has to be coupled, such as Computational Fluid Dynamics (CFD) and Heat transfer. This is the case in LIPT. In such simulations the convergence problems are realistic, and the simulation takes very long time. In literature it has been reported that it would take about 30 days of computational time using 464 processors to simulation 30 minutes flow and thermal behavior in a transformer scale model winding. It means that finite elements tools are nowadays not an option for calculating temperatures in LIPT grid operation. For the same reason, it is also not the realistic option for the transformer thermal design.

A practically applicable method is the detailed Thermal Hydraulic Network model (THNM), for which detailed LIPT construction and basic material characteristics are used as the input data. Two options are of interest: static, for calculation of the temperatures in steady-states, needed for the thermal design of LIPT, and dynamic, for calculation of the temperatures dur-ing transient states, needed for the monitoring system and loading planning during trans-former grid operation. The dynamic model is more complex and more computationally de-manding than the static. Our recent research and development yielded with the conclusion that an idea to build “quasi steady state” model of LIPT, by introducing thermal capacity in the equivalent thermal circuit of metal elements of the transformer, cannot describe properly the heat accumulated in the insulation liquid. The presentation will offer the basics of dynamic detailed THNM, expected to be the dominant future approach in practice.

Prof. Dr. Zoran Radaković, born and educated in Belgrade – 9th Gymnasiums and School of Electrical Engineering, University of Belgrade. Recipient of the "top student" grant from Academy of Sciences and Arts, Belgrade. Received distinction and awarded the student of the generation. The PhD thesis is awarded by the Chamber of Economy of Belgrade for the 1997 year (three awards in a year). Alexander von Humboldt Research Fellowship - the University of Stuttgart, Institute of Power Transmission and High Voltage Technology (IEH). Return Fellow of Alexander von Humboldt-Foundation.

R&D engineer in Siemens AG, Power transformer division, Technology and Innovation, Nuremberg, Germany. Expert position for thermal issues.

Professional, scientific and teaching fields: power transformers, electrical installations, electrical heating, renewable energy (dominantly solar systems), power quality, earthing, compensation of reactive power, power electronics, digital control.

Projects and studies in Serbia: EPS – power stations, EPS - Power utility – studies of power transformer ageing, and Republika Srpska - Power station Visegrad, Transformer factory Comel (Ripanj), Holcim, BVK and large number of projects (including photovoltaic systems) and consultancy services for industry and complex buildings.

Permanent work on foreign markets:

Power transformers – software (https://hostcalculus.com/) and consultancy (Belgium – Pauwels / CG, Italy – Tamini, Getra, Brazil – WEG, Toshiba TSEA, Mexico – WEG, India – EMCO, South Korea – Hyosung, New Zealand – Etel, Uruguay – Salto Grande, Canada – Hydro Quebec).

Power electronics in solar converters – Germany (Delta Energy),

Earthing – UAE – Al Ain Distribution Company,

Power quality – Qatar, Hamad medical corporation – women's hospital and Kazahstan - Kazzinc, Power efficiency and compensation of reactive power – Qatar, Kahramaa.

Revision of large number of projects via Republic revision commission, activities in Serbian engineering chamber, 2 expert witness, Task force leader in Cigre WG A2.38 and A2.60, volunteer work in Institute for standardization,.

Over 130 papers (33 in Journals with impact factors), Scopus: 860 citations, h-index 15, two books, 1 CIGRE Broshure, 1 Patent (USA, China, EU).

Cellulosic materials and new testing techniques - HPSEC determination of cellulose molecular weight

Prof. Dr. Gérard Mortha, Grenoble-INP, LGP2 Laboratory, University of Grenoble-Alpes (UGA), France

The measurement of the MMD (molar mass distribution) of the cellulose molecule in papers is a main characterization that has been the subject of numerous works in the context of studies on the ageing of heritage papers and Art papers. But curiously, very few studies relate to the characterization by this method of electrotechnical papers and their ageing behaviour. For the latter, the approach of measuring the DPv of the cellulose, correlated with the weakening of the physical characteristics of papers (tensile strength, folding resistance), is the common practice.

In this article, we propose to present the principles of the above-mentioned method, namely MMD analysis of cellulose by high-performance size-exclusion chromatography (HPSEC) coupled to multi detectors (viscometry, multi-angle light scattering, refractometry, UV-visible spectrometry), as a particular technique, and it's paper application: advantages, limitations, and some results obtained in our laboratory on different kind of papers, among which electrotechnical papers and their ageing behaviours. In general, one of the important limitations of this measurement is the need to obtain full solubility of the polymer studied in the chosen solvent, organic or aqueous. This condition is difficult to obtain if the paper is made of unbleached cellulosic pulp which contains traces of lignin. This is the case with most Kraft pulps which serve as basic material for electrotechnical papers and pressboards. Lignin must therefore be eliminated prior to paper cellulose dissolution. This is done during a degrading stage called holocellulose which must be inert with respect to cellulose. Achieving total solubility implies having no colloidal matter or aggregates after dissolution. Moreover, the chosen solvent should be a medium in which no interaction between polymer chains or between polymer chain and column matrix should occur. The columns and the solvent must be judiciously chosen. Methods for cellulose dissolution can be ranked into (1) direct dissolution methods, working by solvent complexation of the alcoholic -OH groups carried by the cellulosic chains, and (2) indirect dissolution methods which operate by derivatization of all of the alcohol functions carried by the polymer, and further solubilization of the cellulose derivative in an apolar solvent, such as tetrahydrofuran (THF) which is well suited for HPSEC analysis. The results obtained comparatively by these two methods will be presented and discussed, as well as the advantages and disadvantages of each of the methods. The recent works and publications made on this subject will also be presented and discussed.

Prof. Dr. Gérard MORTHA, Professor at Grenoble Institute of Technology.

Born July 1st, 1961; married with 3 children. PhD in Chemical Engineering from Grenoble-INP (France, 1989) and Post-Doc at the Univ. of Washington (Seattle, USA, 1989). Awarded in 1989 as 1st Grenoble-INP thesis price in chemical engineering and half-national finalist in 1990. Since 1995, he is Associate Professor at Grenoble-INP Pagora/LGP2; he became a full Professor at Grenoble-INP in Sept. 2012.

His expertise covers the areas of Biorefining chemistry & processes (wood pulping/bleaching, chemical engineering, process modelling, mass transfer & thermal aspects, optimization/simulation); lignocellulosic chemistry: raw materials, biopolymers, oxidative & ageing processes; and the chemical analysis of lignocellulosic and derived polymers/materials (wet chemical methods, chromatographic & spectroscopic methods).

He supervised or co-supervised 25 pHDs, 15 post-docs and numerous master students. He co-authored 70 publications, 120 communications in International or French conferences, seminars, 4 book chapters and 5 patents. He participates in specialized conferences of wood chemists (EWLP, ISWFPC) since 1987. He has been involved in one EU project (COST E41, as vice-chairman) and numerous collaborative projects (academic and industrial). He is currently solicited for a French Doctoral Thesis jury in France and in foreign countries (Finland, Sweden, and The Netherlands). He has been heading the chemical research team in LGP2 from 2002 to 2012.

In Pagora, he gives lectures and supervises the lab. works for Engineers & Master students. He is also involved in professional training for pulp mills or chemical suppliers, in the topics of wood pulping/bleaching processes, chemical/thermal engineering, general and analytical chemistry, lignocellulosic chemistry and analysis.

List of 10 significant publications (among the recent ones):

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2. Esakkiammal S.E., Marlin N., Brochier-Salon M.C. and Mortha G., Application of a Universal Calibration Method for True Molar Mass Determination of Fluoro-Derivatized Technical Lignins by Size-Exclusion Chromatography, AppliedChem 2022, 2, 30–47.
3. Walger E., Marlin N., Mortha G., Molton F., Duboc C., Hydroxyl Radical Generation by the H2O2/Cu II/Phenanthroline System under Both Neutral and Alkaline Conditions: An EPR/Spin-Trapping Investigation. January 2021. Applied Sciences 11(2):687.

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The exploitation of optical fibre-based plasmonic sensors for rapid analysis of power transformers insulating oils

Letizia De Maria, RSE, Italy

Optical fibre sensors offer a decisive solution to monitor critical parameters in power transformers, as they can operate safely on electrical equipment. Surface Plasmon Resonance (SPR) is widely exploited as basic detection principle of sensors for different field of application, such as bio and chemical sensing. The implementation in optical fibres makes the remote SPR sensing straightforward and suitable for applications also in presence of high electromagnetic interferences, as in the case of power transformers. In this work, we report an overview on RSE main results of application feasibility of optical sensor based on a synthetic receptor for detection, in oil matrix, of markers of the paper-oil insulating system degradation in oil-filled transformers.

Letizia De Maria received an M.S. degree in physics, from the University of Milan, Italy, in 1985. She started her activities at CISE S.p.A, Milan, on research and development of coherent optical fibre sensors and spectroscopic techniques for industrial applications. She is a senior researcher at RSE Research on Energetic System S.p.A, Transmission and Distribution Technologies Department; her main research focuses on innovative optical sensors for monitoring electrical equipment of the Transmission and Distribution network. She is the author of papers in international journals and proceedings at international conferences. In 2015 she joined the National Electrotechnical Committee (CT10) on “Fluids for Electrotechnical Applications”. Since 2017 she is a Member of the Presidential Council, Italian Society for Optics and Photonics (SIOF).

Mineral oil and esters: Review on DGA interpretation criteria and related mechanism of gas formation

Fabio Scatiggio, A&A Fratelli Parodi, Italy

Liquid insulation, usually in synergy with solid insulation, has been applied in power transformers since the dawn of the electrical industry. The first induction windings, the primitive transformers, the industrial transformers manufactured in 1884, were dry type. Elihu Thompson patented the use of mineral oil in 1887 but only in 1891 mineral oil from crude oil (petroleum) was experimentally used in the insulation of three-phases transformers.

Nowadays, although there are still sectors where the application of dry-type transformers is prevalent, the very large majority of electrical equipment is immersed in insulating liquids.

In recent times some other liquids have been available as alternative to mineral oil. Natural and synthetic esters, just to mention the most popular and applied ones, gained the attention of the electrical market due to some innovative properties unknow in the mineral oils, like: high fire point which reduces the risk of fire, fully biodegradability which drastically limits the environment contamination in case of leakages, high water tolerance which extends transformer life and, sustainability with high CO_2 saving because the source is natural (vegetable).

As well-known power transformer is a sort of black box inaccessible when operating, so electrical tests require the equipment outage.

Anyway, despite of the main purposes of the insulation liquids (the dielectric insulation and the heat dissipation generated from load and no-load losses) additionally insulating liquid acts as an information carrier. By-products formed by degradation of the solid and liquid insulation materials are gaseous, liquid, and solid and if detected their concentration leads to the identification of the state of the transformer.

In other words, insulating fluid is to the transformer what blood is to the human body, and dissolved gas analysis (DGA) is indisputably the most precise technique for assessing the transformer condition.

It's now easy to perceive how important is to exactly know the mechanism of gas formation of the different liquids in order to apply properly the existing criteria of DGA interpretation.

Fabio Scatiggio was born in Venezia, Italy, in 1957. After graduating in chemistry, he was with ENEL and then with Terna Rete Italia as Chemical Laboratory Manager. Currently, he is with A&A Fratelli Parodi as a senior advisor on liquids for electrical applications. He is the Chairman of CT10 (fluids for electrotechnical applications) of the Italian Electrotechnical Committee (CEI). He is a member of many IEC TC10 working groups and convener of PT62975 (in-service natural esters). He is also a full member of CIGRE SC-A2 (transformers) and SC-D1 (emerging materials) and chair of JWG D1/A2.77 (liquid test on electrical equipment). He is also a Senior Member and Reviewing Author for IEEE, and a member of ASTM D27 Committee. Mr Scatiggio has published many scientific papers with a focus on transformers diagnosis by DGA, on problems related to the presence of corrosive sulphur in oil, on transformers' Health Index, on Natural Insulating Esters, on new optical sensors for on-line monitoring, on PCB decontamination techniques, etc. Mr Scatiggio received the "IEC Award 1906" in 2008 and was awarded as "CIGRE Distinguished Member" in 2012.

Insulating oil life cycle: A utility's experience

AE Lombard, Eskom Holdings (SOC), South Africa

The electricity act, Act 42 of 1922, allowed the establishment of the Electricity Supply Commission for which the acronym Eskom became customary. Eskom has remained the major South African utility for the past 100 years. Eskom has thus experienced the evolution of transformer, insulating materials and auxiliary electrical equipment technology. Progress in transformer technology during the early years of the first century was based on experience more than science. Progress during the second century is science based with the applications of rigorous design control procedures to ensure innovative changes are correctly reviewed. This, amongst other, include the utilisation of advanced computer modelling to establish the derivation of a change and foresee all consequences of modifications on the transformer in test or service.

High reliability at lower cost with minimum constructional materials and reduction in size are major requirements. Focus within this industry has also shifted the contribution of "greener" electricity distribution networks. The second century also sees the emphasis on the utilisation of renewable sustainable resources with insulating oils derived from soya, canola, and rapeseed. For Eskom, these crops must be from South African soil, thus expanding the local oilseed value chain upstream through additional farming and agro-processing activities.

Insulating oil has remained a prominent role player in the electrical industry throughout the years. The utilisation and usefulness of measurement of chemical and physical properties of oil are vital to ensure optimised equipment performance and life expectancy. The dependence on oil analyses has escalated over the past few decades and numerous new techniques have been introduced and adopted to analyse oil, determine the degradation and breakdown products as well as contaminants in oil. These analytical results have become critical information in transformer management, condition monitoring programs, plant heath indicators, end of life estimations and fault detection.

This presentation will focus on the application of technology during acceptance, service life and disposal of insulating oil through the utilisation of equipment such as Gas chromatography (GC), X-ray Fluorescence (XRF), Fourier Transform Infrared (FTIR), High Performance Liquid Chromatography (HPLC), Gas chromatography X Gas chromatography - Time of Flight Mass Spectrometry (GCXGC-TOFMS) and Quantitative Evaluation of Minerals Scanning Electron Microscopy (QEMSCAN). Some case studies will be shared where these technologies were utilised to assist in the determination of chemical compounds present in the oil that may have contributed and resulted in electrical equipment deterioration, faults or failure.

Engineers, scientists and especially chemists continue to navigate an exceedingly difficult terrain paved with significant challenges. These are indeed exciting times for the engineering and science fraternities, who must play a leading role towards influencing the energy landscape of our planet.

Annalie Lombard commenced her career during 1981 at Eskom, Johannesburg SA. She obtained her Master's degree in Applied Sciences at Tshwane University of Technology. She completed diplomas in Project management, Manager Development and Small Business Management at Damelin, whilst in Eskom's Applied Chemistry section. During the early 2000's she became the manager of the Eskom Central Flow and Petroleum laboratories at Eskom and decentralised the routine business to 14 branch laboratories in various major South African cities. In 2010 she was promoted to Corporate Specialist for the Eskom Petroleum laboratories focussing on research, technology development and investigations. She has completed numerous related research projects, has authored several publications on oil and insulating gas analysis and was instrumental in providing Eskom with the first PCB testing facility in Africa, as well as a number of standards and procedural works. She is currently the South African representative to IEC TC 10 on electro-technical fluids as well as various CIGRE committees and the Eskom representative on the Doble Engineering USA transformer oil committee.

Stray Gassing of Insulating oils- Transformer condition assessment tool

Anabela Peixoto, EDP Labelec, Portugal

Power transformers are the most expensive and critical equipment in the Electrical System.

Adequate power transformer condition assessment presents several advantages, in terms of increased safety, reduction of direct and indirect costs, increased reliability, among others.

DGA (dissolved gas analysis) is the most recognized tool for transformer monitoring. Depending on the type of gases analyzed, their quantity and the relative abundances of some gases, it is possible to conclude about the condition of the transformer.

However, some oils, under thermal-oxidative stress at temperatures considered usual for normal operating conditions, can produce gases due to its constituents and not connected to an internal fault of the transformer. This phenomenon it is called Stray gassing. The typical gas composition of stray gassing comprises hydrogen, methane and mainly ethane. On the other hand, these gases in certain concentrations, can also arise in the oil as the result of the transformer thermal defects at low temperature (< 300 °C).This situation can promote a diagnostic difficulty: when these individual gases are detected in concentrations above the normal values for the studied population, are we in the presence of a transformer defect or are we in the presence of stray gassing?

In EDP Labelec, the lab procedure of stray gassing specified for new oils (IEC 60296) is applied to oils in service. In this situation, we compare the gases developed after degassing and after thermal stress and compare with the gas obtained for the transformer in service. This method helps the users to differentiate between the genuine fault of a transformer and the stray gassing due to thermal-oxidative stress.

The stray gassing of an oil, however doesn´t mean a problem of the oil, neither a non-compliance with the specification of normal grade oil (limits are only established for high grade oil). Although these issues can confuse the users, there are advantages to reduce the production of the typical gases related with stray gassing (mainly Ethane), and we recommend some methodologies to mitigate the production of these gases.

Anabela Peixoto has a degree in Chemical Engineering and two postgraduation degrees in Management from Lisbon University.

She has been working in the EDP Labelec (company from Energy of Portugal) since 1991, and became the head of the Insulating Materials Department since 2013.

Her professional activity has been focused on the field of monitoring electrical transformers through analysis of oil and paper. She is engaged in CIGRE D1 and A2 and IEC TC 10 activities.

Women in Power

Dr. Jelena Ponoćko, Scottish Power Energy Networks, United Kingdom

The lecture will be presented the IEEE Power and Energy Society (PES), one of the largest and most influential engineering institutions in the world, with over 400,000 members. IEEE is widely known to the scientific and professional public for the development of technical standards, numerous working groups, the most prestigious scientific journals, and international conferences. The lecture will specifically deal with the Women in Power (WIP) initiative within IEEE PES, which is aimed at supporting women in energy, from encouraging young people to education in electrical engineering, through mentoring at the beginning of their careers and career planning, to personal development. As a regular IEEE PES member and representative of WIP Region 8 (Europe, Middle East, and Africa), Jelena will share her experiences on the importance of membership in institutions such as IEEE, not only for personal development but also for wider technical and social impact.

Dr. Jelena Ponoćko, Lead Engineer, Scottish Power Energy Networks, UK, BSc and MSc at the Faculty of Electrical Engineering, University of Belgrade, Ph.D. at the University of Manchester, UK, in the field of flexible consumption management and application of artificial intelligence for electricity consumption profiling. Scientific engagement: Over 50 published papers and technical reports, leading work packages in three Horizon projects, and currently leading the EPRSC project with the University of Manchester.

Monitoring & Diagnostic Center (MDC)

Milan Đorđević, JSC EPS, Serbia

Project "Monitoring & Diagnostic Center", which is for the needs of JSC EPS, are developed by the Electrotechnical Institute "Nikola Tesla" and School of Electrical Engineering, University of Belgrade. The system enables constant insight into the state key power equipment in the three largest power plants in Serbia: power plants "Nikola Tesla" A and B and hydroelectric power plant "Đerdap 1". The goal is better management of key resources in energy production, through continuous monitoring the condition of the equipment, to make the number unplanned downtime due to the cancellation of this equipment reduced to a minimum. The system should serve as a basis for the transition from periodic maintenance to maintenance equipment according to condition. The system will serve as a tool in maintenance and future planning investment. The project "Monitoring & Diagnostic Center" is currently in the second phase implementation. Experts of the Institute "Nikola Tesla" is constantly monitoring the situation key power equipment: generator, block transformer, self-consumption transformers, transformers of the general group and excitation transformer and about it report to the EPS.

The main scope of this project is remote monitoring and diagnostics, updating the measurement database, and reporting for the main power equipment: generators and power transformers.

Main challenges in implementing Monitoring & Diagnostics Center:

- Development & implementation of operational procedure tailored to user's existing operational & organizational schemes
- Providing adequate ICT resources
- Implementation of secure connection
- Integration all the installed monitoring system
- Data acquisition (process data & data from monitoring systems)
- Monitoring system maintenance
- Transition to CBM & RBM

Milan Đorđević, head of the service for the improvement of the technical system of the power plant, from EPS Elektroprivreda Srbije. He is a commissioner for implementing the project "Remote Monitoring and Diagnostic Center" made by the experts from Institute Nikola Tesla.

NOTES

ТЕСЛИНИ ИНОВАЦИОНИ ДАНИ - ТИД
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ISBN 978-86-83349-18-0