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Superconducting Multifunctional Transmission Line Fundamentals

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Abstract: Primary Superconductors Multifunctional Transmission Line (SCMTL) engineering basic project built on High Temperature Superconductors (HTSCs) Interior Optimization (IO) and Molecular Effect Model (MEM) previous research series is explained and detailed. Results comprise fundamental design of SCMTL and functional applications with several HTSCs materials. Advantages and inconvenients of SCMTL project are evaluated. A number of applications are presented. Transmission Lines (TLs) and optimization in several electric power installations types are shown.

Keywords : Interior Optimization (IO) Methods, Graphical Optimization, Isotope effect (IE), Critical temperature [Tc], Inverse Least Squares (ILS), Electronics Superconductors (SC), High-Temperature Superconductors (HTSC), [Tl-Sn-Pb-Ba-Si-Mn-Mg-Cu-O] Molecular HTSC Group, Molecular Mass (MO), Molecular Effect Model (MEM), Transmission Lines (TL), Power Transmission Lines (PTL), Superconducting Multifunctional Transmission Line (SCMTL).

INTRODUCTION

Following a series of superconductors and high-temperature superconductors series, this study presents the Superconducting Multifunctional Transmission Line (SCMTS) basic concepts and design. An SCTMS is defined [42-46,52] as follows,

Definition I.-A Superconducting Multifunctional Transmission Line (SCMTL) is a multi-operative transmission line adaptable on electrical/magnetic power energy supplies/demands optimization in function of environmental/artificial temperatures and electrical power parameters [Casesnoves, 2021] .

PTL design is mainly based on three science and engineering foundations. Namely, Power Engineering, Electromagnetism Physics Maxwell Theory and Electromagnetic Theory, and Applied/Theoretical Mathematics [42-54]. Statistical Optimization takes also an important role of the advances in this field. In general, the design, manufacturing and maintenance of a PTL is complex [42-54] and depends on multiple factors. For the objectives of this study, the most important are, materials conductors, overheating and overloading, insulation and coatings, electrical and magnetic parameters, and environmental ones [1,4-6,42-54]. Additionally, for conventional PTL, corrosion, biological contamination, lubrications, plating and aging/life-expectancy are also significant.

The PTLs common materials are aluminum, copper and steel. Their electrical resistivity difference, compared to any superconductor, either Type I or II, is enormous in magnitude. Currently, energy demands are increasing in industrial world significantly, and the prospective demands expectations for next times show be very high [7]. This implies that innovative use of superconductors could reduce energy losses and decrease the electrical power production and consumption costs.

The basic property of superconductors is not the main advantage of a SCMTL. A significant problem in PTLs is the overloading and overheating. Overloading could be sorted by far with superconductor materials. Overheating also, because of the functional-operative temperatures of superconductors. Cooling cost, however, constitutes an economical strain. Moreover, optimization of power demands could be dealt better with combination of superconductors in a SCMTL design.

A SCMTL is a cylinder-shaped structure whose internal structure has several encircled layers. The layers and central line could be formed by conducting, superconducting, or HTSCs materials. It could be coaxial or pair line also. The innermost layer may be formed by a conventional conductor—for electrical power engineering standard transmission. From inner structure to outwards one, several stratums of divided/different HTSCs and/or superconducting circular layers/covers could be installed. Cooling covers/stratums are between any subsequent superconductors or HTSCs classes.

From inner direction to outwards one, Figure 1, every HTSC magnitude of T_C is decreasing/increasing according to design conditions. For the most external superconductor layer has the maximum/minimum T_C magnitude. Consistent with electrical power engineering requests, the operational usage could be from one to all superconducting layers working at the same time or in successive intervals. Multiple optimization options are possible. Even the conventional inner conductor could be working singularly according to electronics-thermodynamical and/or environmental energy constraints at any time.
Thus, the innovation of this research is to present a new primary design for SCMTLs. Fundamentals are explained and technically justified. Applications, advantages and inconvenients are evaluated in the project from an engineering and electronics physics criteria.
In summary, SCMTL offers theoretically prospective applications both for electrical power engineering and wave TLs.

ELECTRONICS PHYSICS INVENTION BASIS

This SCMTL line has capability to transmit electrical power at a wide range of temperatures, depending on the engineering resources and power energy demand [1,4-6,42-54] .
The energy demands at industrial countries and increased electrical power use has increasing prospective use for future [7]. Both for electrical power transmission and electromagnetic waves Tls energy losses represent a severe difficulty for operational/economical optimization.
Minimization of the electrical resistance is an optimal possible method to avoid electrical power loss transmission lines diminution. HTSCs and standard superconductors materials could work out that hurdle. If the engineering design/operative-functionality perform properly. In addition, the HTSCs and superconducting materials manufacturing/maintenance costs should be moderate [42-46].
In power SCMTL, the electrical power savings are principally linked to significant materials resistance diminution. Figure 1 shows the basic structure of a SCMTL [42-46]. The main parts are:
Cylinder-shaped structure encircled layers of conducting and HTSCs materials.
Conventional structure, coaxial, parallel or pair line (not applicable).
Optional superconducting materials resistance distribution: from lower to higher or inversely T_C magnitude, from inner part towards external part.
Cooling layers optimal distribution.
Optional operative functions. The use of a number of HTSCs and/or superconductors combined with/without conventional transmission material(s).
Thermodynamical multiobjective optimization for all T_C magnitudes.
Magnetic fields created by the superconductors and/or HTSCs layers while power conducting could be synergic also and increase the efficiency by modifying better the T_C magnitude.

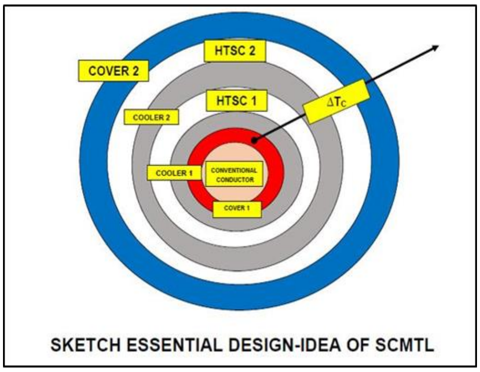

Figure 1.- From [46], basic design of a SCMTL. HTSC1 , first superconductor type, HTSC2 the second one with higher T_C . Direction of T_C increase [arrow] marked with arrow. Conventional conductor at center [42-46]. This is a simple idea-design.

Interior Optimization of Isotope Effect and Molecular Effect for optimal design applications

In former publication series [1,4-6,42-46], Interior and Graphical Optimization Methods were developed, together with Molecular Effect Model/Hypotheses (MEM) for Types I and II superconductors. Further, MEM constitutes an important prospective technique for HTSCs combinations in object. These extensive dataset can be applied for optimal T_C design at SCMTLs. Figures 2-3 show examples of 2D and 3D MEM and Interior and Graphical Optimization of superconductors and HTSCs. Figure 4 proves the utility of Genetic Algorithms Software Engineering for HTSCs. Both 2D/3D/4D Interior/Graphical Optimization and Isotope/Molecular Effects models could be suitable for the presented project.

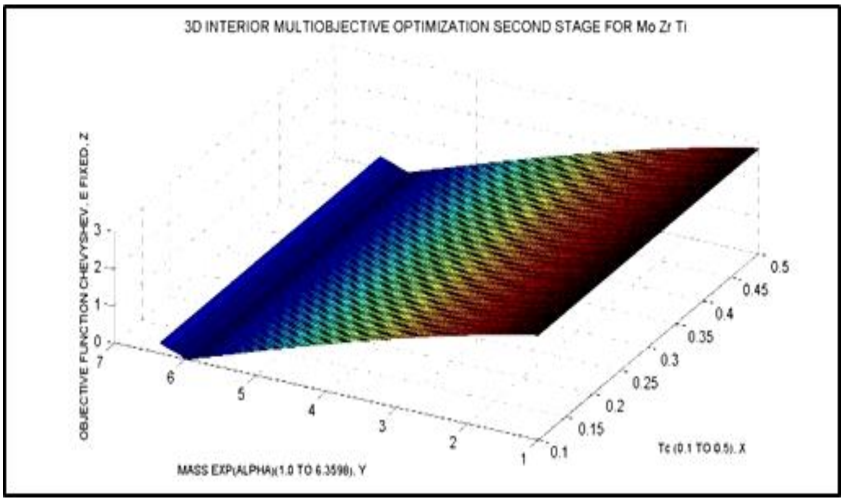

Figure 2 .- From [6], second stage of Interior-Graphical Multiobjective Optimization for Mo Zr Ti. It was determined the optimal E value was fixed from first stage, E=2.909. It was selected the E1 value of Table 3. Intervals are in legends of graphs 4, 5, and 6. Numerical results are detailed in [Table 3, 6].

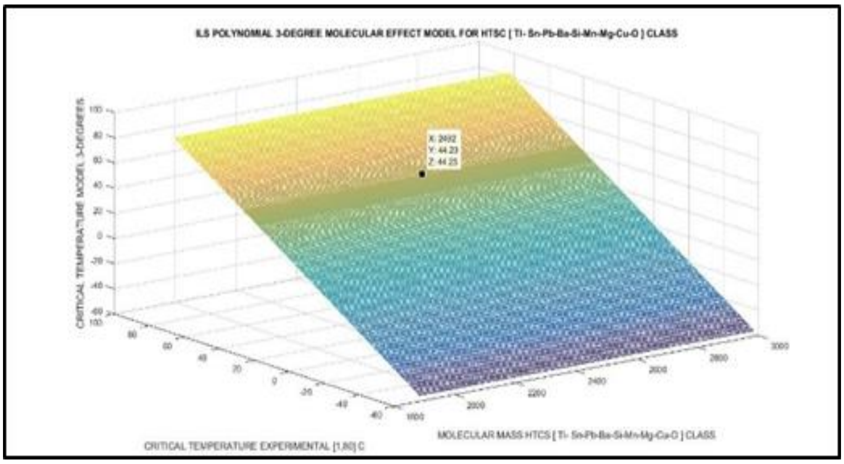

Figure 3.- From [44], 3-Degree polynomial MEM 3D graph showing model T_C prediction and 3D experimental data which are approximately equal. The HTSCs class for this software graphical optimization is [Tl-Sn-Pb-Ba-Si-Mn-Mg-Cu-O] . Molecular HTSC Group Numerical example coincidence between experimental and MEM data is marked. Note the dark zone at surface that means the transition between negative and positive T_C for the MEM. This matches the 2D results of Figures 3,4,5. At Z axis MEM data with imaging processing method 2. Matrices for 3D Graphical Optimization are [300 x 300].

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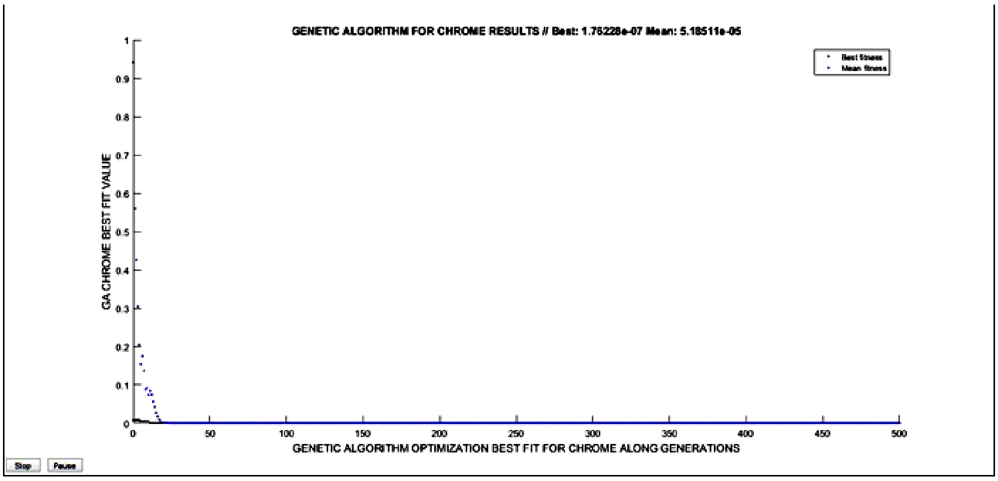

Figure 4 .- From [52], example Interior Optimization of Chrome Isotopes with Genetic Algorithms. The Chrome GA results (first stage optimization) for best fit along has generations (500). Results show be accurate [52].

POWER ENGINEERING APPLICATIONS

The prospective applications of SCMTL are theoretically wide. There are TLs for waves, generally, and electrical power TLs. All of them get advantages theoretically from SCMTLs. However, the most useful to save energy is the electrical power TLs. In waves TLs, distance from surface of HTSC, is inversely proportional to power loss. This difficulty is sharply attenuated by the superconducting effect [47-54]. Table 1 shows a functional analysis of SCMTLs and Table 2 presents their prospective applications.

ANALYSIS OF FUNCTIONS OF SCMTL	
ADVANTAGES	**INCONVENIENTS**
High voltage/intensity performance	Not very long connections for high-voltage and current demand at Supercomputers installations
Optimization for energy demands	High reparation/maintenance costs
Very high energy cost reduction	Magnetic/electrical field environmental contamination and risks. Costs for shielding.
Additional use of magnetic fields created by current	Cooling systems design/maintenance necessary
Sorting Overheating and Overloading problems	A number of design/manufacturing difficulties proportional to length of SCMTLs

Table 1.-Primary evaluation of SCMTL project advantages and inconvenients on applications for power engineering and electronics physics.

PRIMARY APPLICATIONS OF SCMTL		
USAGE FIELD	**ENGINEERING**	**COMMENTS ADVANTAGES/INCONVENIENTS**
High performance computational laboratories/ Supercomputers	Not very long connections for high-voltage and current demand at Supercomputers installations	Possible with technical difficulties. Very useful for varying high-electrical power demand of Supercomputing installations.
Medical Technology Apparatus	MRI or similar medical devices that create high magnetic fields due to very high electrical intensity	Possible with technical difficulties. The same reasons than above.
Transport based on Magnetic Fields levitation tracks. [levitation train, manly]	Magnetic field levitation based on superconductor that create very high magnetic fields	Much more difficult
Aerospatial Stations	High electrical intensity and/or magnetic fields required for Spatial Station technology	Much more difficult

Table 2.-Primary fundamental applications of SCMTLs. Just remark that those are primary applications [1,4-6,42-54] .

DISCUSSION AND CONCLUSIONS

The objective of the contribution was to present the basic engineering project for a SCMTL. Foundation ideas and prospective applications are shown. The base of superconducting effect through increasing magnitudes of T_C and layers distribution was presented. Previous research series of Interior and Graphical Optimization for Isotope Effect and Molecular Effect in SCs and HTSCs were explained for project design [4-6, 20, 46-51].

The project innovation is given by energy demands losses, budgets reduction, and power demands optimization. Multiple applications, Table 2, constitute a number of plusses.

Advantages for electrical power engineering are the savings of both resistance (impedance with attenuation factors) and other losses of conventional PTLs related to electrical resistance. Inconvenients are given by the manufacturing, repairing, and maintenance costs [4-6, 20, 46-54].

In brief, an initial SMTL project was explained at basic stage. Applications for electrical power engineering are wide with several prospective substantial energy production increase. Diverse uses for several technology fields emerge from the project.

SCIENTIFIC ETHICS STANDARDS

SCMTL project was created by Dr Casesnoves on 15th March 2022. The Molecular Effect Model for HTSCs was set applied for SCMTL by Dr F Casesnoves on 15th March 2022. All the papers series of Superconductors and HTSCs are different in text, images (unless an image citation is necessary), programming applied and conclusions. Usually every Superconductor or HTSC element/class study starts with previous 2D optimization and steps up to 3D optimization in subsequent study/articles. Basic algorithms are used in series with equal structure but different parameters magnitudes/intervals. Matlab software is original from the author in all 2D/3D and Numerical Optimizations results presented [2-6,42-46]. 2D/3D Graphical Optimization Methods were created by Dr Francisco Casesnoves in 3rd November 2016, and Interior Optimization Methods in 2019. 2D/3D/4D furher

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Graphical and Interior Optimization Methods were created by Dr Francisco Casesnoves in 2020. This article has previous papers information, whose inclusion is essential to make the contribution understandable. This study was carried out, and their contents are done according to the European Union Technology and Science Ethics. Reference, 'European Textbook on Ethics in Research'. European Commission, Directorate-General for Research. Unit L3. Governance and Ethics. European Research Area. Science and Society. EUR 24452 EN [38-41]. And based on 'The European Code of Conduct for Research Integrity'. Revised Edition. ALLEA. 2017. This research was completely done by the author, the computational-software, calculations, images, mathematical propositions and statements, reference citations, and text is original for the author. When a mathematical statement, proposition or theorem is presented, demonstration is always included. If any results inconsistency is found after publication, it is clarified in subsequent contributions. The article is exclusively scientific, without any commercial, institutional, academic, religious, lobbies of any kind, religious-similar, non-scientific theories, personal opinions, political ideas, friends or relatives favours, or economical influences. When anything is taken from a source, it is adequately recognized. Ideas and some text expressions/sentences from previous publications were emphasized due to a clarification aim [38-41].

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Dr Francisco Casesnoves earned the Engineering and Natural Sciences PhD by Talllinn University of Technology (started thesis in 2016, thesis Defence/PhD earned in December 2018, official graduate Diploma 2019). Dr Casesnoves is European Union and Internationally qualified as Doctor in Engineering to supervise PhD Theses, Master Theses, and Bachelor Theses in science and engineering. He works as independent research scientist in computational-engineering/physics. Dr Casesnoves earned MSc-BSc, Physics/Applied-Mathematics (Public Eastern-Finland-University, MSc Thesis in Radiotherapy Treatment Planning Optimization, which was developed after graduation in a series of Radiation Therapy Optimization-Modelling publications [2007-present]). Dr Casesnoves earned Graduate-with-MPhil, in Medicine and Surgery [1983] (Madrid University Medicine School, MPhil in Radioprotection Low Energies Dosimetry [1985]). He studied always in public-educational institutions, was football player 1972-78 (defender and midfielder) and as Physician, supports healthy life and all sports activities. Casesnoves resigned definitely to his original nationality in 2020 for ideological reasons, democratic-republican ideology, ethical-professional reasons, anti-state monarchy corruption positions, and does not belong to Spain Kingdom anymore. His constant service to the International Scientific Community and Estonian technological progress (2016-present) commenced in 1985 with publications in Medical Physics, with further specialization in optimization methods in 1997 at Finland—at the moment approximately 100 recognized publications with approximately 70 DOI papers. His main branch is Computational-mathematical Nonlinear/Inverse Methods Optimization. Casesnoves best-achievements are the Numerical Reuleaux Method in dynamics and nonlinear-optimization [books 2019-2020], the series of Radiotherapy Improvements for AAA superposition-convolution model, the Graphical and Interior Optimization Methods [2016-8], the new Computational Dissection-Anatomical Method, [2020], invention of Forensic Robotics [2020-2021], Molecular Effect Model for High Temperature Superconductors [2020], and Superconducting Multifunctional Transmission Line [2021-2]. Dr Casesnoves PhD thesis is an Estonian scientific service to European Social Fund and several EU Research Projects. Dr Casesnoves scientific service since 2016 to the Free and Independent Republic of Estonia for technological development (and also at Riga technical University, Power Electrical and Electronics Department) is about 40 physics-engineering articles, two books series, and 1 industrial radiotherapy project associated to Europe Union EIT Health Program (Tartu University, 2017).