Integrarea soluțiilor digitale pentru controlul parametrilor de funcționare în instalațiile de producere a energiei electrice și căldurii cu zero emisii de CO_2

\- *Etapa 3 a cercetării* –

(perioada ianuarie – iunie 2024)

Echipa de cercetare:

As. dr. ing. Daniel DIMA

Drd. ing. Mihnea COSTIN

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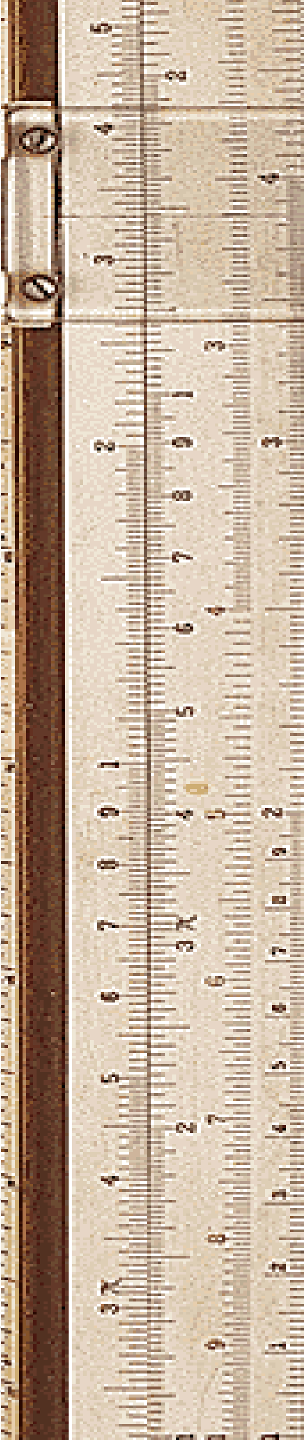
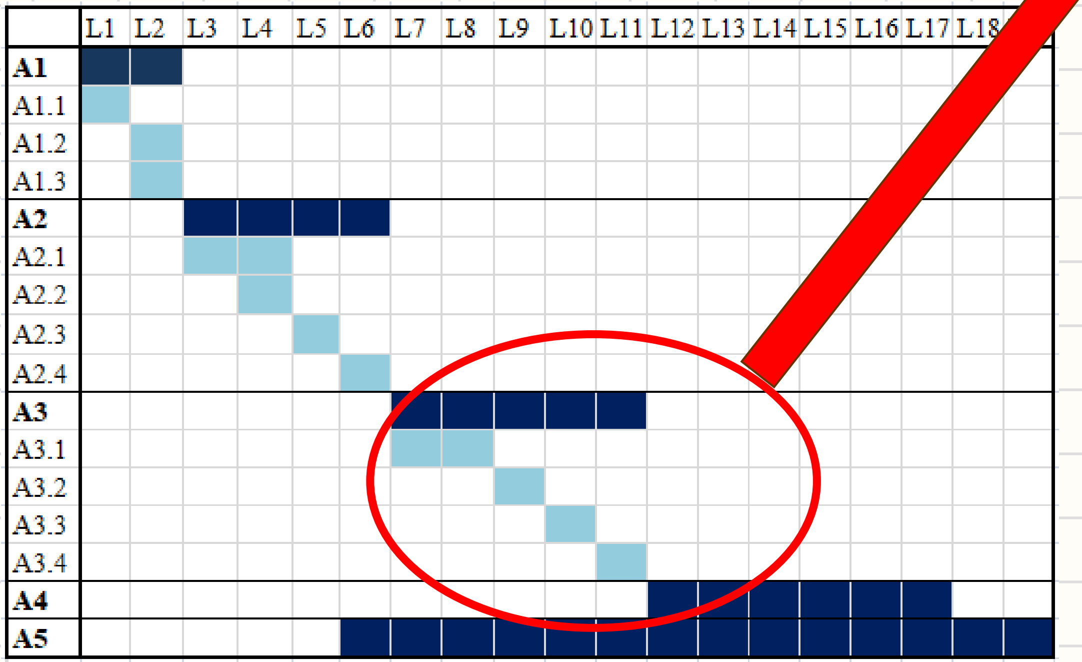
Director proiect:

Conf. dr. ing. Cătălina DOBRE

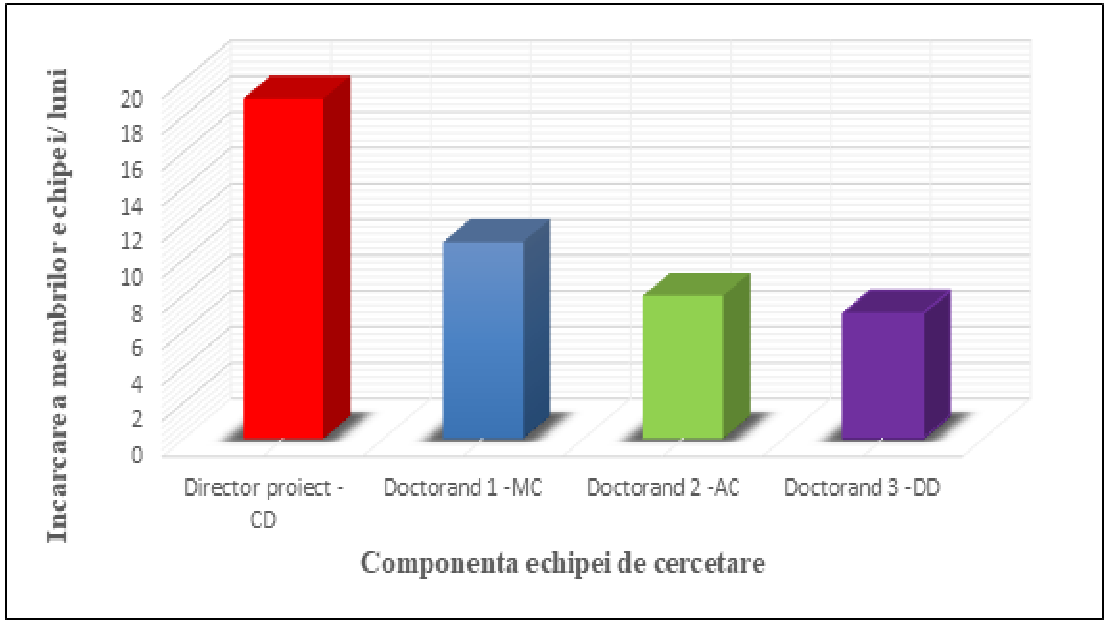


Perioada	Obiective	Activități	Rezultate livrate pe etapă
Ianuarie 2024– Iunie 2024	Optimizarea structurală și funcțională a sistemului de producere a energiei electrice necesare locuintei construite in zone izolate	A1. Identificarea solutiilor optime de captare a energiei solare (ansamblul concentrator-receptor) A2, Simularea ciclului Stirling solar pentru producerea energiei energiei electrice	*Raport de cercetare ştiinţifică a sistemului de producere a energiei electrice si caldurii necesare locuintei*

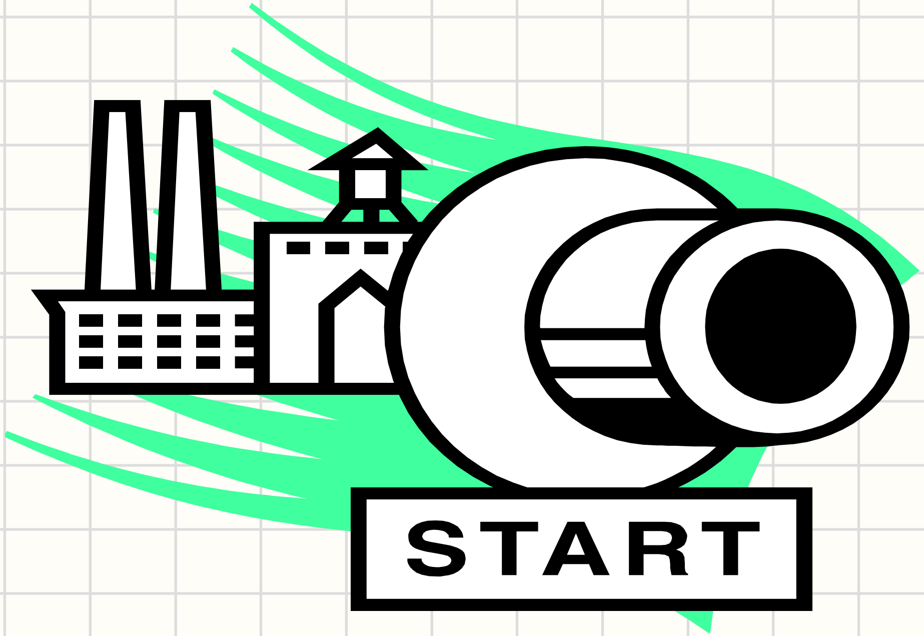


	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14	L15	L16	L17	L18	
A1	■	■																	
A1.1	▨																		
A1.2		▨																	
A1.3		▨																	
A2			■	■	■	■													
A2.1			▨	▨															
A2.2				▨															
A2.3					▨														
A2.4						▨													
A3							■	■	■	■	■								
A3.1							▨	▨											
A3.2									▨										
A3.3										▨									
A3.4											▨								
A4												■	■	■	■	■	■		
A5						■	■	■	■	■	■	■	■	■	■	■	■	■	■

Graficul Gantt



Gradul de implicare al membrilor echipei de cercetare activităţile proiectului.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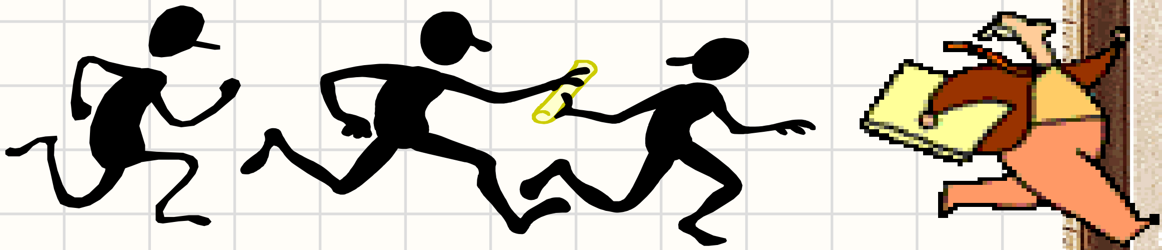
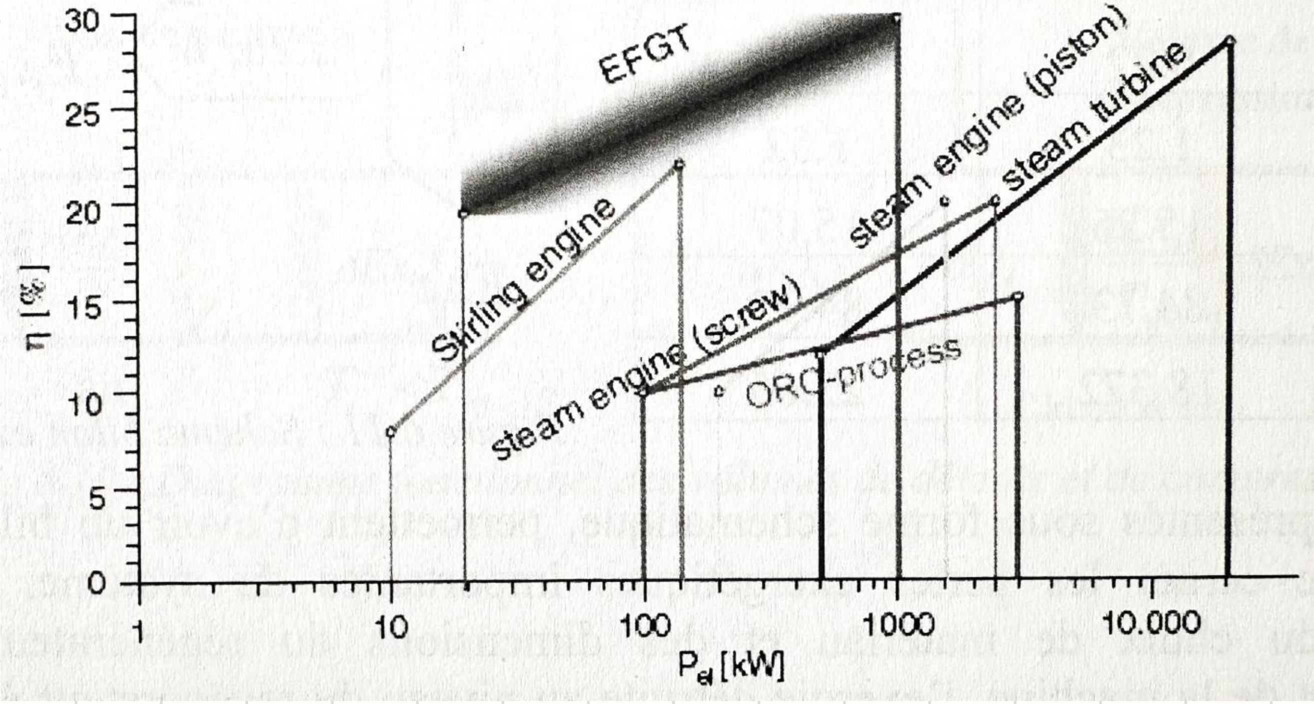


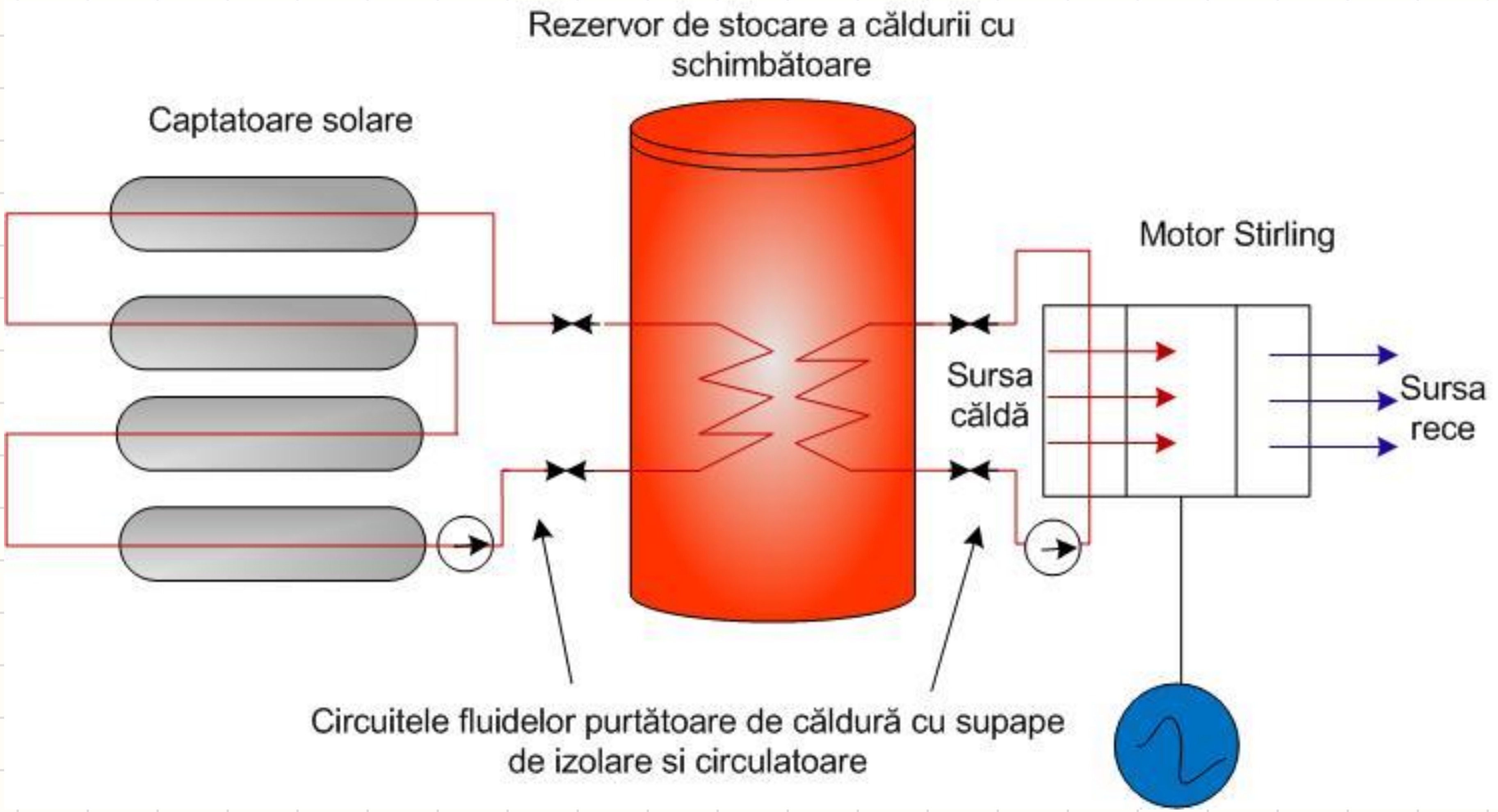
Comparatie intre motoarele Stirling si instalatiile cu abur sau gaz pentru o temperatura a sursei calde de 950oC [*Kautz et al., 2007*].



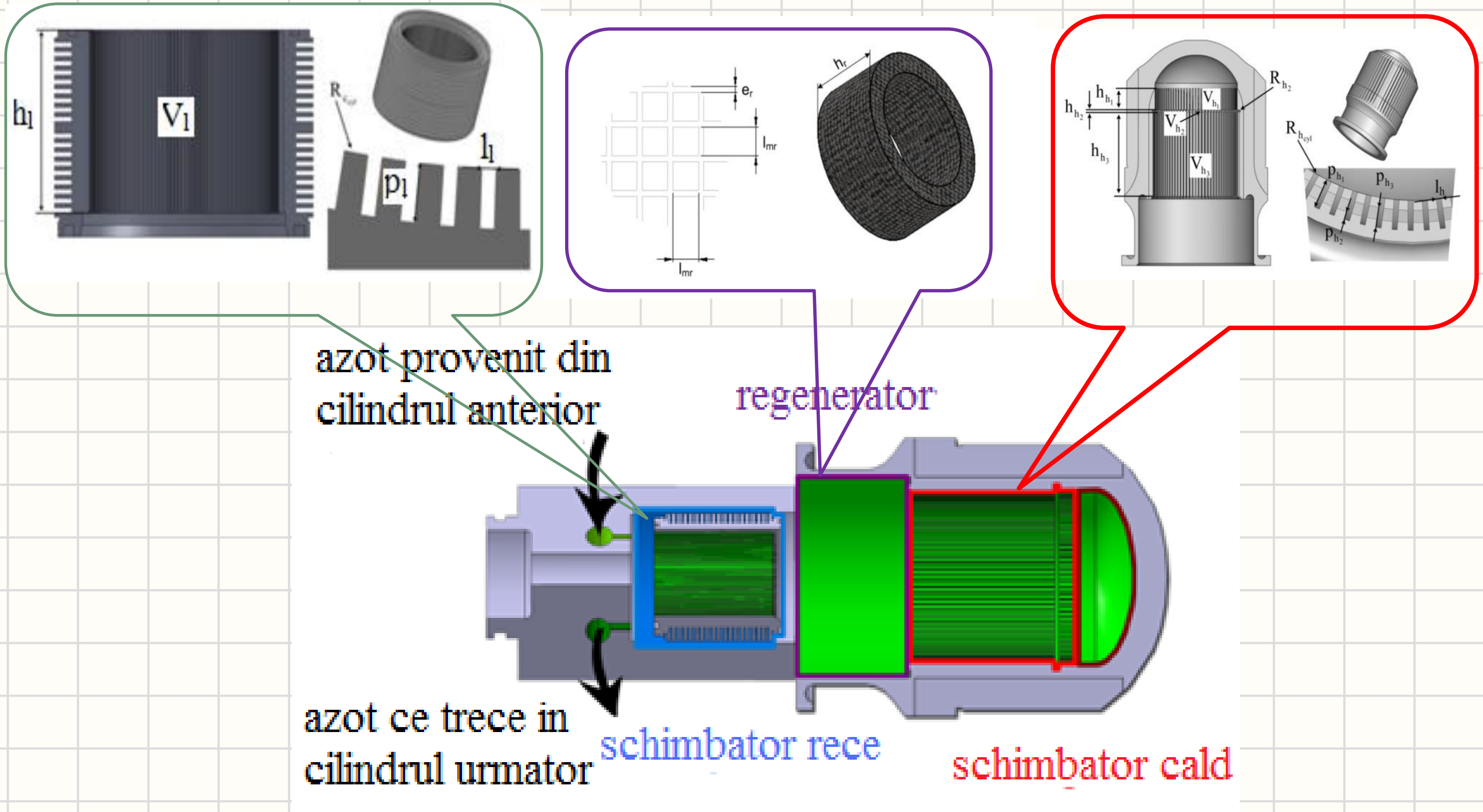
Compartie intre 2 tipuri distincte de tehnologii utilizate pentru producerea electricitatii (Turbine cu abur si motoare Stirling) [*Gorssek et al., 2003*].

Diferite tehnologii	Interval de puteri	Randament global	Durata de viata
Turbina cu abur	>1MWe	12-25%	medie
Motor Stirling	1 - 100 kWe	7-12 %	ridicata

Prezentarea sistemului studiat



Dispunerea schimbatoarelor de caldura in motorul Stirling analizat



azot provenit din
cilindrul anterior

regenerator

azot ce trece in
cilindrul urmator

schimbator rece

schimbator cald

Metoda Directa

Randamentul motorului Stirling este:

$$\eta_{SE} = \eta_{CC} \cdot \eta_{II,irev} = \left(1 - \frac{T_l}{T_h}\right) \cdot \eta_{II,irev}$$

unde:

$$\eta_{II,irrev} = \eta_{II,X} \cdot \eta_{II,\Delta T} \cdot \eta_{II,\Delta p}$$

Coeficient de pierderi regenerative

Randamentul consecinta al Principiului II:

$$\eta_{II,X} = \frac{1}{1 + \frac{\boxed{X} \cdot c_v}{R \cdot \ln \varepsilon} \cdot \left(1 - \frac{T_l}{T_h}\right)}$$

$$\eta_{II,\Delta T} = \left(1 + \sqrt{\frac{T_h}{T_l}}\right)^{-1}$$

Randamentul consecinta al celui de al II lea Principiu ce tine seama de pierderi de presiune:

Pierderi datorate vitezei pistonului

Pierderi datorate laminarii in regenerator

Pierderi datorate frecarii

$$\eta_{II,\Delta p} = 1 - \frac{\frac{w_p}{w_{S,L}} \cdot \gamma \cdot \left(1 + \tau^{\frac{1}{2}}\right) \cdot \ln \varepsilon + \frac{C w_g^2}{p_{min}}}{\tau \cdot \eta_{CC} \cdot \eta_{II,X} \cdot \ln \varepsilon} - \frac{\frac{3 \cdot \left(0.94 + 0.045 \cdot w_p\right) \cdot 10^5}{4 \cdot p_{min}}}{\tau \cdot \eta_{CC} \cdot \eta_{II,X} \cdot \ln \varepsilon}$$

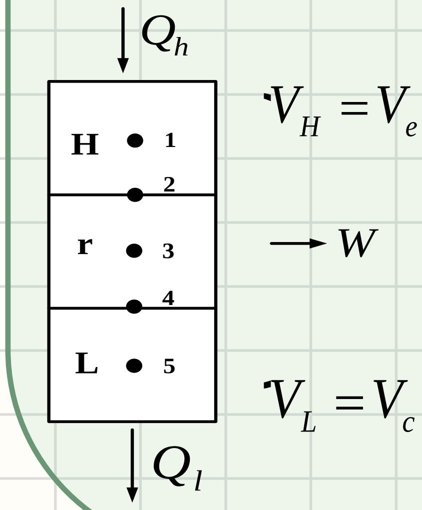
Model izoterm (Schmidt). Model adiabatic (Finkelstein)

Ipoteze

- **gaz de lucru=gaz perfect**
- **masa fluidului constanta**
- **temperatura peretelui constanta**
- **miscare sinusoidala a pistoanelor**
- **turatia constanta**
- **regenerare imperfecta** $\eta_{reg} = 0.8$

Model izoterm

temperatura gazului este omogena in volumele cald si rece



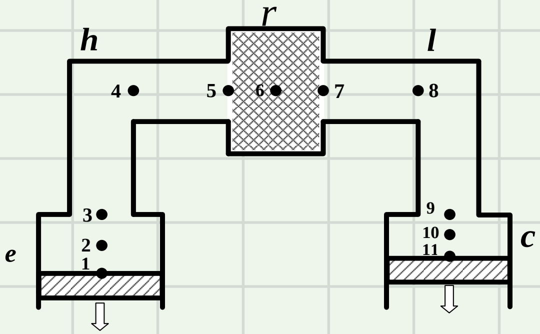
$$V_H = V_e + V_h + V_{me}$$

$$V_L = V_c + V_l + V_{mc}$$

Model adiabatic

volumele de comprimare si destindere sunt adiabate

Volumele schimbatoarelor de caldura sunt izoterme



$$V_e = \frac{V_{e0}}{2}\left(1 - cos(\omega t + \varphi_i\right)$$

$$V_c = \frac{V_{c0}}{2}\left(1 - cos(\omega t + \varphi_i - \varphi_0\right)$$

Masa fluidului

$$\begin{cases} m_c = \dfrac{pV_c}{RT_{10}};\ m_l = \dfrac{pV_l}{RT_8};\ m_r = \dfrac{pV_r}{RT_6} \\ m_h = \dfrac{pV_h}{RT_4};\ m_e = \dfrac{pV_e}{RT_2} \end{cases}$$

Presiunea instantanee

$$p = \frac{mR}{\dfrac{V_e}{T_e} + \dfrac{V_h}{T_h} + \dfrac{V_r}{T_r} + \dfrac{V_l}{T_l} + \dfrac{V_c}{T_c}}$$

Cantitati elementare de caldura

$$\begin{cases} \delta Q_l = \dfrac{c_v}{R} V_l\, dp - c_p (T_7\, dm_7 - T_9\, dm_9) \\ \delta Q_r = \dfrac{c_v}{R} V_r\, dp - c_p (T_5 dm_5 - T_7\, dm_7) \\ \delta Q_h = \dfrac{c_v}{R} V_h\, dp - c_p (T_3\, dm_3 - T_5\, dm_5) \end{cases}$$

Lucrul mecanic elementar

$$\begin{cases} \delta W_c = -pdV_c \\ \delta W_e = -pdV_e \end{cases}$$

Date caracteristice punctului de functionare

n	T_h	T_l
$[rot/min]$	$[K]$	$[K]$
1500	750	333

Rezultate experimentale

	$\dot{W}_{el}$ [kW]	η_{el} [%]	$\dot{Q}_{th}$ [kW]	η_{th} [%]	$\dot{Q}_{comb}$ [kW]
Experiment 1 [literatura]	1	12	6.66	80	8.33
Experiment 2 (laborator Ville d'Avray)	1	9.8	6.73	66	10.2

$$\eta_m = 0.87$$

$$\dot{W} = \frac{\dot{W}_{el}}{0,87}$$

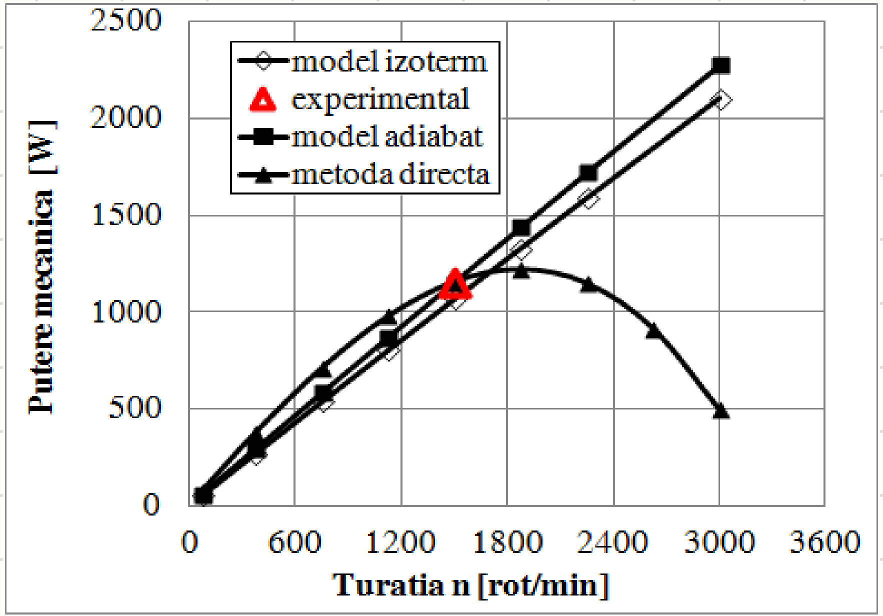
$$W = \frac{\dot{W}_{el}}{0,87} \cdot \frac{60}{n}$$

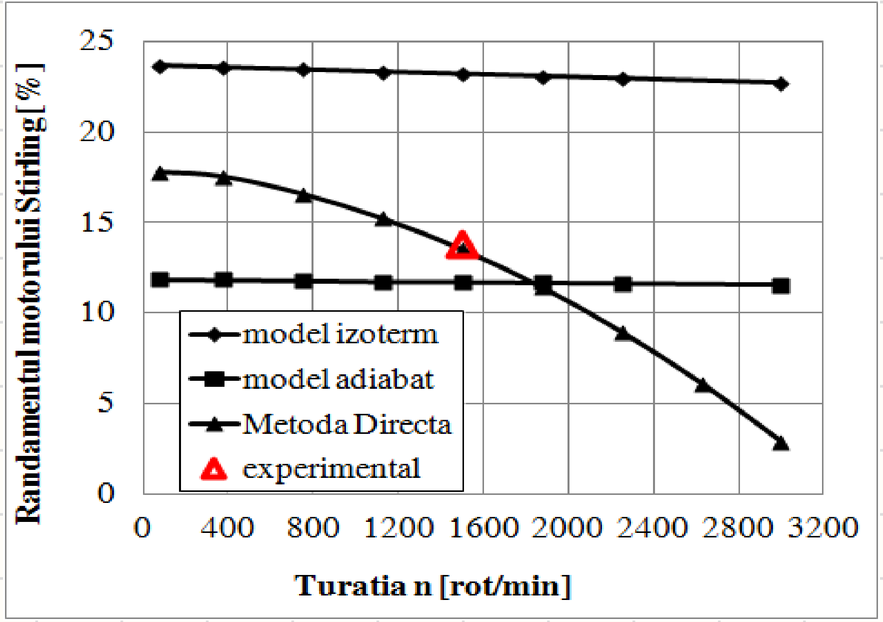
$$\eta_{Stirling} = \frac{\eta_{el}}{0,87}$$

Comparatia rezultatelor

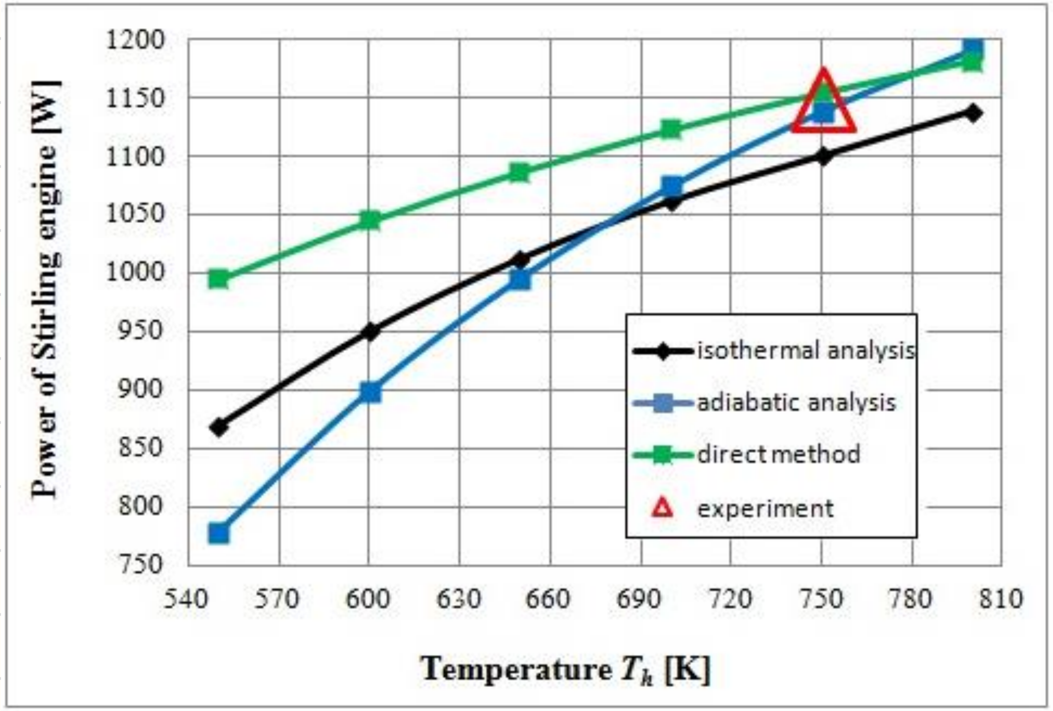
	Metoda Directă	Model izoterm	Model adiabatic	Experiment 1	Experiment 2
W [J/ciclu]	47.26	42.64	46.12	46	46
$\dot{W}$ [W]	1181.4	1065.6	1153	1150	1150
$\eta_{Stirling}$ [%]	13.8	23.21	11.73	13.8	11.2

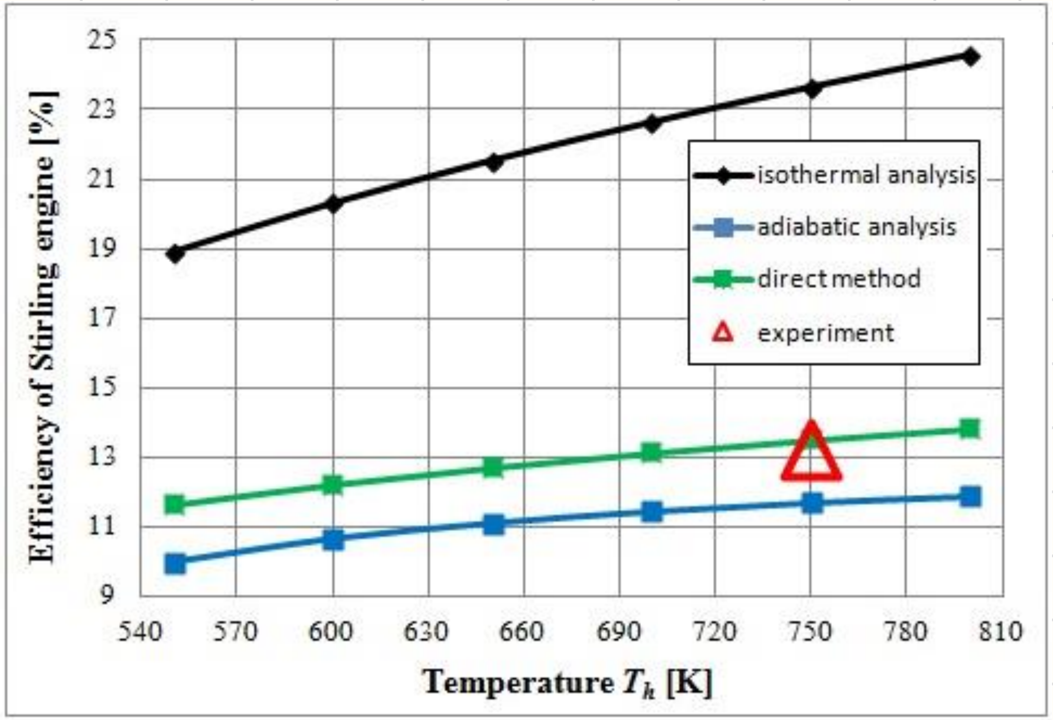
Studiu parametric





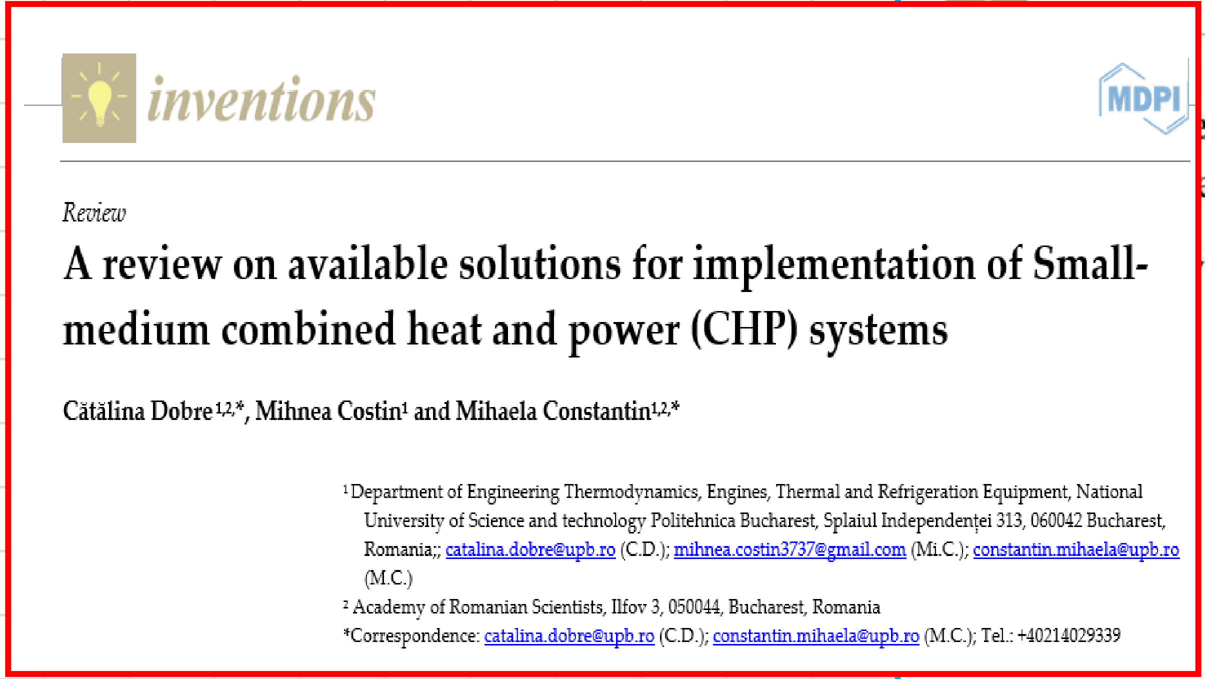
Comparison results simulation-experiment for several temperatures of hot volume





Obiective specifice:

OS 5. Valorificarea rezultatelor cercetării întreprinse prin publicarea acestora în 2 reviste de renume indexate WOS şi creşterea vizibilităţii lor p



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Review

A review on available solutions for implementation of Small-medium combined heat and power (CHP) systems

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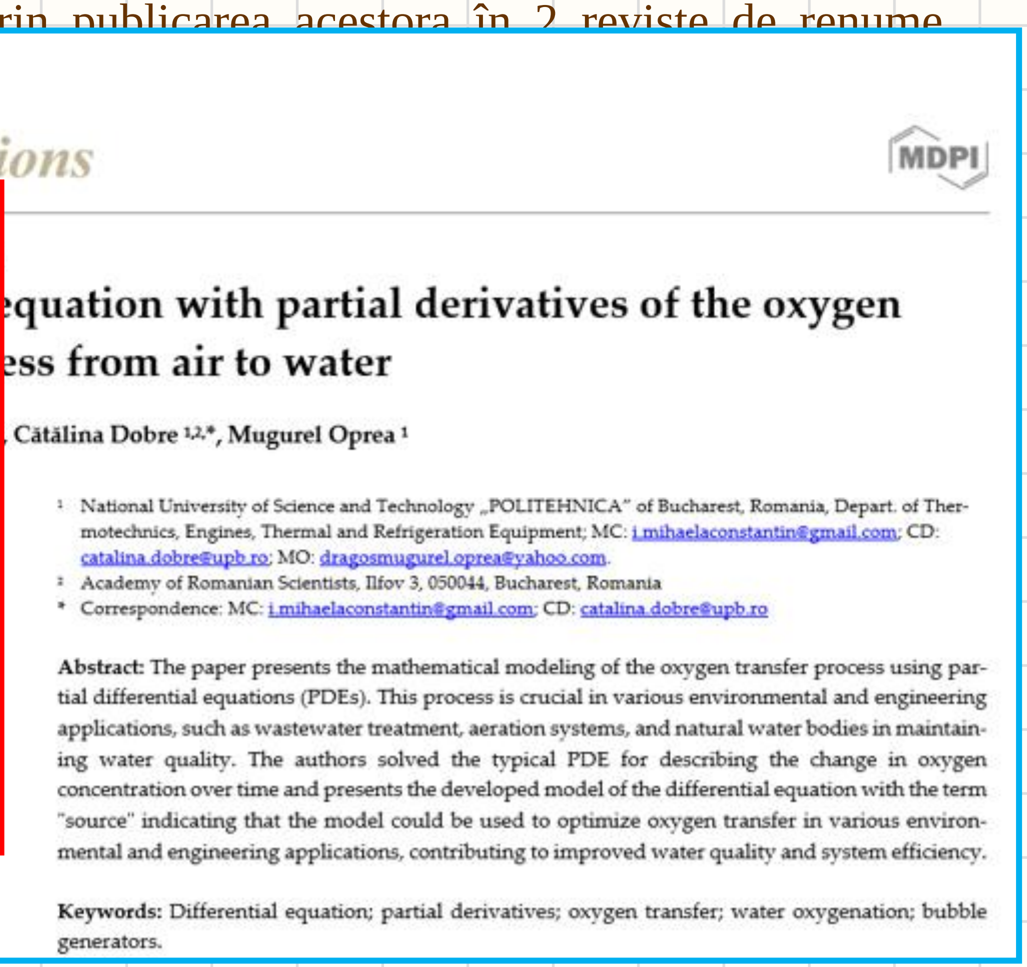

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equation with partial derivatives of the oxygen ess from air to water

, Cătălina Dobre[1,2,*], Mugurel Oprea[1]

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Abstract: The paper presents the mathematical modeling of the oxygen transfer process using partial differential equations (PDEs). This process is crucial in various environmental and engineering applications, such as wastewater treatment, aeration systems, and natural water bodies in maintaining water quality. The authors solved the typical PDE for describing the change in oxygen concentration over time and presents the developed model of the differential equation with the term "source" indicating that the model could be used to optimize oxygen transfer in various environmental and engineering applications, contributing to improved water quality and system efficiency.

Keywords: Differential equation; partial derivatives; oxygen transfer; water oxygenation; bubble generators.

Mulțumesc pentru atenție!