



Cairo University

**STEADY AND TRANSIENT NUMERICAL INVESTIGATION OF
AUTO-IGNITION CHARACTERISTICS OVER MICRO-
STRUCTURED CATALYTIC HONEYCOMB REACTORS FOR CH₄
AND CH₄-H₂ MIXTURES**

By

Alaa Mohamed Ahmed Abdel Raziq Mohamed

A Thesis Submitted to the
Faculty of Engineering at Cairo University
In Partial Fulfillment of the Requirements for the Degree of
MASTER OF SCIENCE
In
MECHANICAL POWER ENGINEERING

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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Key Words:

Combustion; Auto-Ignition; Catalyst; Transient; Methane

Summary:

In this study, stable range of self-ignition for the micro-combustion of CH₄ and CH₄-H₂ mixtures have been investigated over platinum-coated micro catalytic honeycomb reactor by CFD technique using CHEMKIN and ANSYS17.2 Packages. A certain amount of heat is furnished from outside at constant temperature with an external electric furnace to investigate localized self-ignition temperature. This investigation studies the effect of flow rate and mixture strength. Noting that, Ignition of mixtures occurs at same temperature for different mass flow rates of CH₄-Air mixtures, while it is decreased for increased flow rates of CH₄-H₂-Air mixtures. Equivalence ratio for CH₄ mixtures is found to be within different range from traditional self-ignition combustion.



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عنوان الرسالة:

دراسة عددية ثابتة ولحظية لخصائص الإشعال الذاتي فوق مفاعلات حفازة ميكروهيكلية شكل خلية النحل لغاز الميثان وخليط من غازي الميثان – الهيدروجين

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ملخص الرسالة:

في هذه الدراسة، يتم تناول مدى استقرار درجة حرارة الإشعال الذاتي للإحتراق على المستوى المتناهي الصغر لغاز الميثان وخليط من غازي الميثان والهيدروجين داخل مفاعلات حفازة ميكروهيكلية شكل خلية النحل مغطاة بالبلاتينيوم بواسطة تقنية الدراسة العددية لديناميكا الموائع من خلال برنامجي CHEMKIN و ANSYS17.2. يتم تزويد كمية معينة من الحرارة من الخارج عند درجة حرارة ثابتة باستخدام فرن كهربائي خارجي لدراسة درجة حرارة الإشتعال الذاتي المحلية. تبحث هذه الدراسة عن أثر معدل التدفق ونسب ومكونات الغاز. يلاحظ أن، الإشتعال يحدث عند نفس درجة الحرارة لمختلف معدلات تدفق غاز الميثان بينما تقل مع زيادة معدل تدفق غازي الميثان والهيدروجين. وجدت نسبة التكافؤ لغاز الميثان في مدى مختلف عن النسبة المعتادة للإشعال الذاتي في الإحتراق التقليدي.

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List of Symbols

1	K	Thermal conductivity, w/m.k
2	A_{int}	Active internal surface area per unit length, cm ² /cm
3	A_{ext}	External heat transfer area per unit length, cm ² /cm
4	A_{flow}	Cross sectional flow area, cm ²
5	h	heat transfer coefficient, w/m ² .k
6	μ	Viscosity, kg/m.s
7	ε	Emissivity,
8	cp	Specific heat of fluid, J/kg.K
9	g_i	The component of the gravitational vector in the i^{th} direction, m/ s ²
10	\dot{q}	Wall heat flux, W/m ²
11	S_u	The source term
12	S_ϕ	The source term
13	T_i	Inlet temperature, °C
14	T_p	Temperature at the cell adjacent to wall, °C
15	T_w	Temperature at the wall, °C
16	\vec{u}	The flow velocity vector, m/s
17	\bar{u}_i	The mean velocity component, m/s
18	u_j	Mean velocity component, m/s
19	U_p	Mean velocity of the fluid at point P , m/s
20	t_w	Cell Wall Thickness ,mm
21	D_r	Diameter of reactor ,cm
22	L_r	Length of reactor ,cm
23	D_{cell}	Cell Size/diameter ,cm