Sudan University of Science and Technology
College of Graduate Studies and Scientific Research

Producer Gas Based Absorption Cold Storage

التخزين المبرد الإمتصاصي القائم على الغاز الصناعي

Submitted for Partial Fulfillment of the Degree of M.Sc. in Mechanical Engineering

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آيات

أعوذ بالله من الشيطان الرجيم

قـــال تعـــالى:

أَفَرَأَيْتُمُ النَّارَ الَّتِي تُورُونَ ﴿71﴾ أَأَنتُمْ
أَنشَأْتُمْ شَجَرَتَهَا أَمْ نَحْنُ الْمُنشِؤُونَ ﴿72﴾
نَحْنُ جَعَلْنَاهَا تَذْكِرَةً وَمَتَاعًا لِلْمُقْوِينَ ﴿73﴾
فَسَبِّحْ بِاسْمِ رَبِّكَ الْعَظِيمِ ﴿74﴾ الواقعة

DEDICATION

This work is dedicated to my parents, brothers, sisters and my wonderful fiancée.

HASSAN BADAWI
2013

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I thank **God** for His awesome grace in letting me see this work to its completion.

I would like to express my deepest gratitude to the Head of Power Department in SUST, **Dr. Mohyedin Ahmed** , for the supervision and support he provided during my efforts to accomplish this work. Many thanks also go to staffs and colleagues of the power Department at School of Mechanical Engineering who worked with me in the various aspects of this study. I gratefully thank **Dr. Tawfig Ahmed**, the director of the mechanical engineering school for his help, encouragement and for his constructive comments on this research. I am also indebted to **Dr. Elkawad Ali**, the deputy dean of Post Graduation Studies College at SUST for his moral support which he provided during the course of this study.

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Abstract:

This study is conducted to design a cold storage refrigeration cycle using a generated energy of producer gas from agricultural residues and other available trees in Sudan as prosopis juliflora to store vegetables and fruits. The cold storage dimensions, thickness of required insulation, unit and capacity of gasifier, also the link between the calculations of cold storage heat load and the required capacity of gasifier have been determined.

The desired design of cold storage is intended for Kurdufan state to preserve milk, meet, vegetables and fruits; (Abujibaiha, Malam Elkour, and Tajmala are taken as examples to save some perishable fruits and vegetables

Experiments have been done on a fabricated absorption refrigeration unit of 3 tonnage of refrigeration using an electrical heating as a similar load instead of 15 metric ton of mangoes.

Finally a comparison was made between the experimental results of the absorption system and a compression one, which gives an economical feasible result.

المستخلص:

بنيت هذه الدراسة على الاهتمام بتصميم مخزن تبريد يعمل بالدورة الامتصاصية باستخدام الطاقة المتولدة من الغاز الصناعي الناتج من استخدام الكتلة الحيوية لبعض النباتات المتوفرة بكثرة في السودان مثل نبتة المسكيت أيضا المخلفات الزراعية لتخزين الخضروات و الفواكه بولاية كردفان.

ولقد تم في إطار هذه الدراسة حساب أبعاد مخزن التبريد و الحمل الحراري وحساب سمك العازل المطلوب و أجزاء الدورة الامتصاصية ووحدات توليد الغاز الصناعي المطلوبة والربط بين حسابات الحمل الحراري للمخزن وسعة وحدة توليد البيوغاز المطلوبة.

المطلوب تصميم مخزن تبريد يعمل عن طريق الدورة الامتصاصية باستخدام طاقة الغاز الصناعي في مناطق انتاج الفواكه والخضرارات والألبان واللحوم بولاية كردفان، أخذت مناطق مثل (أبوجبيهة وتجملا، وملم الكور) كنماذج للدراسة لحفظ الفواكه والخضار.

أجريت تجارب على وحدة تبريد امتصاصي صغيرة بسعة 3 طن تبريدي تحاكي في حملها التبريدي منتج مقدر بكمية 15 طن متري (حمل كهربائي) وقد تم رصد درجات الحرارة ومعدلات تدفق لماء التبريد ووسيط التبريد كما تم رصد تغذية الكتلة الحيوية المقترنة معها.

أخيرا تمت مقارنة نتائج التبريد الإمتصاصي على وحدة مع وحدة انضغاطية حيث أعطى نتيجة اقتصادية مقبولة.

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SYMBOLS AND ABBREVIATIONS

SYMBOLS:

NO.	Symbol	Coding	Unit
1.	Efficiency	eff.	%
2.	Mass or capacity	M	Kg
3.	Volumetric loading rate	C_v	Kg/m^3
4.	Surface loading rate	C_A	Kg/m^2
5.	Product Height	H_p	M
6.	Floor area	A_p	m^2
7.	Floor utilization factor	η_A	-
8.	Temperature	T	°C or K
9.	Volume occupied by products	V_P	m^3
10.	Temperature difference	dT, ΔT	K
11.	Density	ρ	Kg/m^3
12.	Coefficient of thermal conductivity	Ḱ	W/m.k
13.	Specific heat at constant volume	Cv	J/kg k
14.	Calorific value	CV	kJ/kg
15.	Specific heat at constant pressure	Cp	J/kg k
16.	Heat transfer coefficient	U	$W/m^2.k$
17.	Material thickness	δ_x	M
18.	Heat transfer coefficient of a particular substance	a	$W/m^2.k$

19.	Freezing temperature	T_F	°C
20.	The amount of latent heat of evaporation	$L = h_{fg}$	J/kg
21.	Specific heat of a material above the freezing point	C_{P1}	KJ/kg k
22.	The amount of heat transmitted	T_F	W
23.	Latent heat of freezing a material	L	KJ/kg k
24.	Area of the outer surface	A	m^2
25.	Specific heat of a material below the freezing point	C_{P2}	KJ/kg k
26.	Specific heat of a box substance	C_{P3}	KJ/kg k
27.	Specific volume of fresh air outside	V_a	m^3/Kg
28.	outside air enthalpy	h_a	KJ/kg
29.	Indoor air enthalpy	h_i	KJ/kg
30.	Interior cold storage room volume	V_R	m^3
31.	lighting a day period	H	h/24h
32.	heat generated by workers	Q_w	KW
33.	Working hours	τ	Hours
34.	Evaporators Cooling capacity	E_C	KW
35.	Evaporator Capacity of mangoes room	E_{CM}	KW
36.	Evaporator Capacity of potatoes room	E_{CP}	KW
37.	The amount of heat generated by engines	Q_m	KW
38.	The amount of heat generated by lighting	Q_L	KW
39.	Air changing load	Q_A	KW

40.	Heat generated by respiration	Q_R	KW
41.	Heat withdrawn from boxes	Q_C	KW
42.	Heat withdrawn due to cooling below freezing	Q_P	KW
43.	Lighting rate	P	W
44.	Evaporator Capacity	E_C	KW
45.	Condenser pressure	p_c	Bar
46.	Evaporator pressure	p_0	Bar
47.	Electrical energy input,	W	KW / KW h

ABBREVIATIONS

NO.	Symbol	Coding
1.	COP	Coefficient Of Performance
2.	VCRS	Vapour Compression Refrigeration Systems
3.	VARS	Vapour Absorption Refrigeration Systems

Subscripts

4.	AB,a	Absorber
5.	B	Biomass
6.	C,c	Condenser
7.	E,e	Evaporator
8.	Exp	Experimental
9.	G	Generator
10.	RC	reflux condenser
11.	r	Real
12.	1-24	state points in the system with reference to Figure (4-1)

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