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Research Article

COMPARATIVE STUDY AND ANALYSIS OF PERFORMANCE REFRIGERATION SYSTEM DRIVEN BY DIFFERENT ENERGY SOURCES

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ABSTRACT

The present work concerns a study on mechanical compression refrigeration machines that based on the electric compressor, and absorption machine, were this work is focused on choosing natural gas as a direct source in the refrigeration space; this logic was present general thermodynamic calculations of the two machines. The results show that quite good values of the coefficient of performance of the new configuration of the absorption refrigeration machine and the study of the cost of each one, we can consider it encouraging for the development of this device, which promises to be an alternative one hand to eliminate the pressure in the electricity sector, and promises to be quite powerful economic and energy point of view and side environment.

Keywords: refrigeration system; mechanical; absorption machine; Energy; Cop.

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1. INTRODUCTION

The search for better living conditions and comfort has led humans to intensify their consumption of energy in its various forms (oil, gas, coal, electricity, etc.). This has led to adverse effects on the planet, such as atmospheric pollution, the greenhouse effect, desertification, melting glaciers, ozone layer perforation, etc.

The households sector accounted for more than the third of all the energy used in Algeria and, it's the largest energy using sector. To provide further understanding it is Useful to examine the demand for all residential energetic services. .Energy use in the sector includes energy for cooling, heating, lighting, cooking, washing, and other appliance. To estimate the final energy use, it's necessary to determining energy use for each one of these components alone

Global awareness of the dangers facing the earth has led researchers and industry to develop rational and efficient ways of using energy in industrial processes.

In this context, the upgrading of waste heat generated by many industrial processes, through cooling machines, is an attractive measure at the energy and economic levels.

To achieve this objective, two categories of refrigerating machines can be considered:

Compressor refrigeration machines; Absorption refrigeration machines;

Compressor refrigeration machines are the most widespread, which relegates the other two types to limited or marginal uses. But the recent ban on the use of CFCs as working fluids in mechanically compressed heat pumps due to their implications for the destruction of the ozone layer offered a prospect for the development of absorption refrigeration machines [7].

Based on these considerations, this work is in line with the development of the refrigerating absorption machine and the search for alternative refrigerants that are less aggressive to the environment [1]. The aim of this work is to use natural gas for the production of refrigeration using an absorption refrigerating machine, which uses refrigerants which do not have an adverse effect on the environment, and reduce the consumption of the electrical energy; Price is clearly an important factor in discussing energy presents residential energy prices for electricity, natural gas. These were chosen as these fuels make up the majority in residential sector,very low prices of electricity and gas in Algeria, and this very low prices are effecting the energy consumption in encouraging the households to consume more.

2. Compression refrigeration system

The most common steam compression refrigeration system operates with a refrigerant in a closed circuit comprising a compressor, condenser, expansion unit, evaporator and connecting piping (Figure I.2), condenser by heat transfer (Q_C) to the surrounding medium [8].

The pressure of the refrigerant in the liquid state is reduced in the regulator. At low pressure and low temperature, the refrigerant vaporizes, allowing the heat (Q_F) to be extracted from the substance to be cooled. To complete the cycle, at the outlet of the evaporator, the low pressure refrigerant vapor is compressed and brought to high pressure by the compressor. The total heat rejected at the condenser corresponds to the sum of the heat extracted on the evaporator and the energy consumed by the compressor [6].

Figure 1 shows the main elements of a refrigeration machine with simple mechanical compression as well as its thermodynamic cycle.

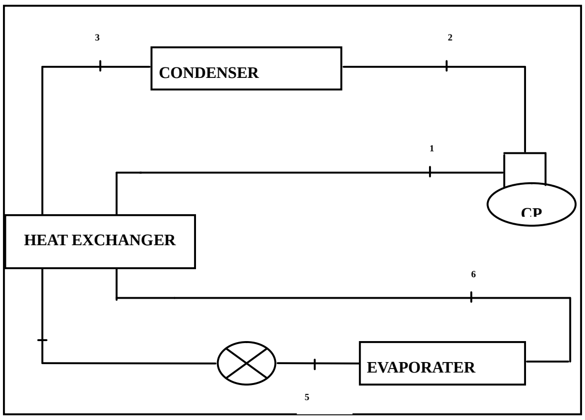

Fig.1. Refrigeration machine with mechanical compression

2.1. Thermodynamic analysis

$$\mathbf{Cop} = \frac{q_{0m}}{w_m} \qquad \text{(I.1)}$$

$$w_m = h_2 - h_1 \qquad \text{(I.2)}$$

$$q_{0m} = h_1 - h_4 \qquad \text{(I.3)}$$

$$p_t = Q_m . w_m = Q_m . (h_2 - h_1) \qquad (I.4)$$

3. Absorption refrigeration machine

Absorption chillers are generally classified as director indirect-fired, and as single, double or triple-effect. Indirect-fired units, the heat source can be gas or some other fuel that is burned in the unit, such as a boiler or heat recovered from an industrial process. Hybrid systems, which are relatively common with absorption chillers, combine gas systems and electric systems for load optimization and flexibility.advantages: Elimination of the use of CFC and HCFC refrigerants, Quiet, vibration-free operation Lower pressure systems with no large rotating components, High reliability, Low maintenance [5], Single-effect LiBr/H2O absorption chillers use low-pressure steam or hot water as the heat source [4]. The water is able to evaporate and extract heat in the evaporator because the system is under a partial vacuum. The thermal efficiency of single-effect absorption systems is low. Although the technology is sound, cost competitiveness of single-effect systems. Most new single-effect machines are installed in applications where waste heat is readily available, The operating principle of an absorption machine is the same as For a conventional compression system, with a refrigerant which vaporizes At low temperature (production of cold) and condenses at higher temperatures (Heat rejection). Absorption refrigeration machines can be used to replace Vapor phase of the refrigerant by liquid phase compression of a binary solution. This solution consists of refrigerant and an absorbent. The amount of energy Electric power consumed by the pump is almost negligible. However,A heat source to dissociate the refrigerant from the absorbent and be able to operate in a closed cycle [2]. The principle diagram of this type of machine is shown in figure 2.

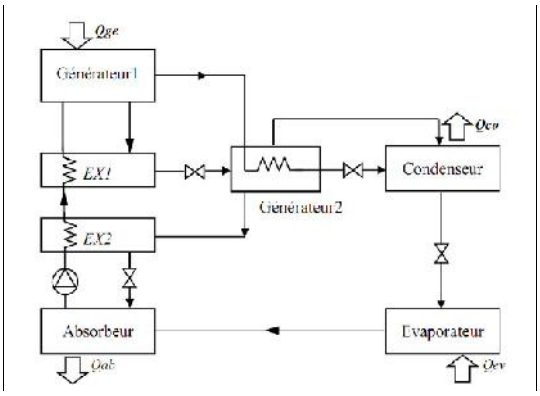

Fig.2. Double Effect -acting absorption refrigeration system

Double Effect: The desire for higher efficiencies in absorption chillers led to the development of double-effect LiBr/H_2O systems. The double-effect chiller differs from the single-effect in that there are two condensers and two generators to allow for more refrigerant boil-off from the absorbent solution [3]. The higher temperature generator uses the externally-supplied steam to boil the refrigerant from the weak absorbent. The refrigerant vapor from the high temperature generator is condensed and the heat produced is used to provide heat to the low temperature generator [11].

These systems use gas-fired combustors or high pressure steam as the heat source. Double-effect absorption chillers are used for air-conditioning and process cooling in regions where the cost of electricity is high relative to natural gas. Double-effect absorption chillers are also used in applications where high pressure steam, such as district heating, is readily available. Although the double-effect machines are more efficient than single-effect machines, they have a higher initial manufacturing cost.

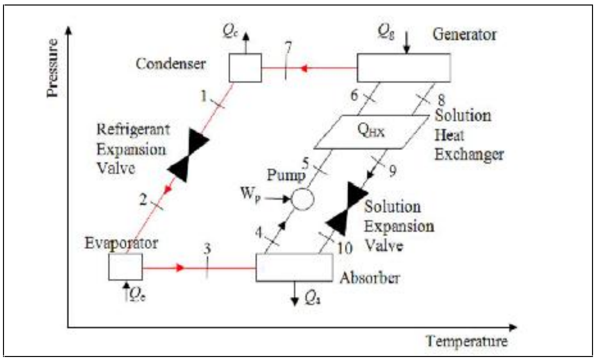

Fig.3. Thermodynamic cycle of absorption refrigeration system

3.1. Thermodynamic analysis

$$\textbf{COP} \quad = \frac{\Phi_e}{\Phi_g} = \frac{Q_m(h_{10}-h_9)}{Q_m h_7 + Q_{msr} h_1 - Q_{msp} h_6} \qquad \text{(I.5)}$$

$$\Phi_g = Q_m h_7 + Q_{msr} h_1 - Q_{msp} h_6 \qquad \text{(I.6)}$$

$$\Phi_c = Q_m (h_7 - h_8) \qquad \text{(I.7)}$$

Efficiencies of absorption chillers are described in terms of coefficient of performance (COP), which is defined as the refrigeration effect, divided by the net heat input. Single-effect absorption chillers have COPs of approximately 0.6 to 0.8 out of an ideal 1.0. Since the COPs are less than one, Double-effect absorption chillers have COPs of approximately 1.0 out of an ideal 2.0 [9].

4. RESULTS AND DISCUSSION

The study of the influence of certain parameters on the coefficient of performance in the mechanical compression refrigeration machine and also in the absorption refrigeration machine is to find the optimal values in order to improve the operation.

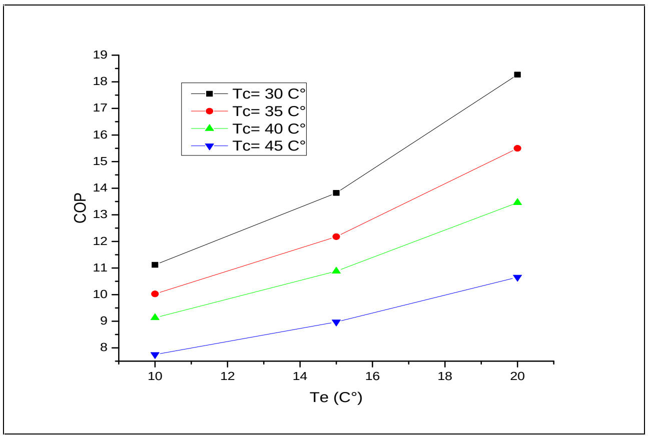

Fig.4. Influence of evaporator temperature on COP

Figure 4 shows the variation of the COP as a function of evaporator temperature for various condenser temperature values It is found that the variation of the COP increases with the decrease in the condensation temperature (thus a good cooling of the ff), and the COP increases with the increase of the evaporation temperature. (The work of compressions decreases, so the COP increases).

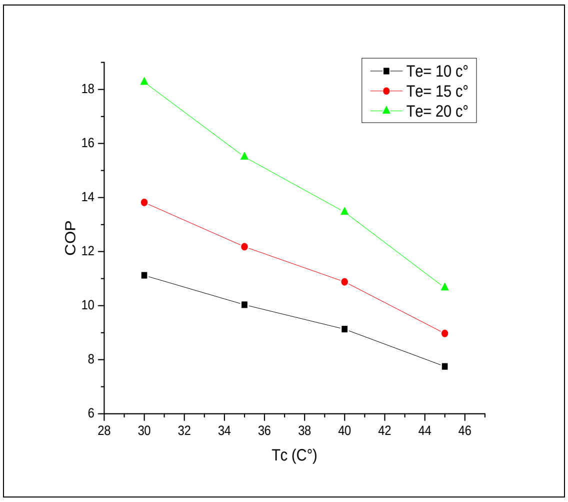

Fig.5. Influence of condenser temperature on COP

Figure 5 shows the variation of the COP as a function of the temperature of the condenser for varying temperature values of the evaporator The results show that the temperature rise of the condenser decreases the COP value (this directly affects the cooling of the ff at HP at the condenser) and, on the other hand, for a relatively high evaporation temperature (temperature of Air conditioning), the COP increases. This means that the refrigeration machine reaches the desired temperature without the compressor providing an important compression work.

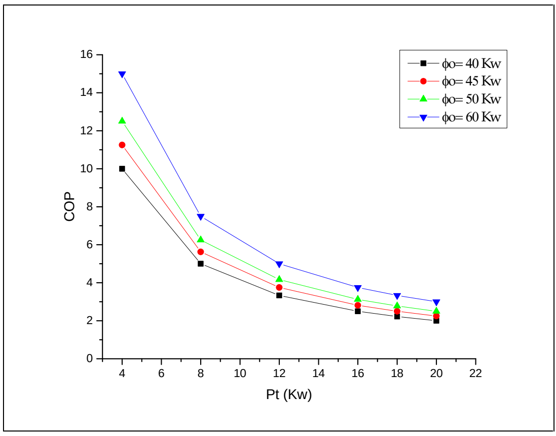

Fig.6.Influence of the compressor puissance on COP

Figure 6 shows the variation of the COP as a function of the theoretical power for different refrigerating power values The results show that the COP increases by reducing the theoretical power consumed by the compressor, a better COP is obtained for a reduced compression work (it is known that the compression work influences the theoretical power consumed by the compressor according to thermodynamic calculation) it can be seen that the COP is proportional to the refrigerating power and inversely proportional to the theoretical power consumed by the compressor.

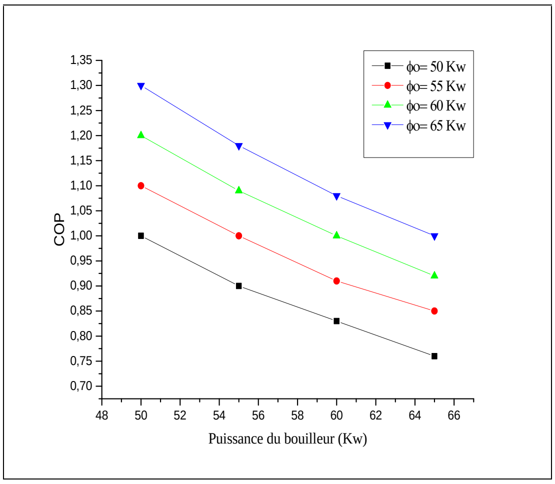

Fig.7. Influence of boiler power on the COP

Figure 7 shows the variation of the COP as a function of boiler power for different refrigerating power values. The COP decreases with increasing boiler power. (The COP is inversely proportional to the boiler power, if (ϕ_b) increases thus high cost.

Table.1. Energy cost using mechanical refrigeration system for different COP values

		ϕo (kwh)	0,014	0,02	0,022	0,03	0,045	0,05	0,07
Electric	**COP= 2,5**	Pt (KWh)	0,005	0,008	0,008	0,012	0,018	0,02	0,028
		Euro (€)	0,023	0,034	0,037	0,051	0,076	0,085	0,119
		Dinars (DZ)	2,594	3,706	4,077	5,560	8,340	9,266	12,973
	COP = 5	Pt (KWh)	0,002	0,004	0,004	0,006	0,009	0,01	0,014

	Euro (€)	0,011	0,017	0,018	0,025	0,038	0,0426	0,059
	Dinars (DZ)	1,297	1,853	2,038	2,780	4,170	4,633	6,486
COP= 8	Pt (KWh)	0,001	0,002	0,002	0,003	0,005	0,006	0,008
	Euro (€)	0,007	0,010	0,011	0,015	0,023	0,026	0,037
	Dinars (DZ)	0,810	1,158	1,274	1,737	2,606	2,895	4,054

Table1 presents a comparison between the cost of consumption between electricity and natural gas.

Table.2. Energy cost using Absorption refrigeration system for different COP values

	ϕo (KWh)		0,014	0,02	0,022	0,03	0,045	0,05	0,07
Absorption	**COP= 0,2**	ϕb (KWh)	0,07	0,1	0,11	0,15	0,225	0,25	0,35
		Euro (€)	0,011	0,016	0,018	0,024	0,037	0,041	0,058
		Dinars (DZ)	1,263	1,805	1,986	2,708	4,062	4,513	6,319
	COP= 0,8	ϕb (KWh)	0,017	0,025	0,027	0,037	0,056	0,062	0,087
		Euro (€)	0,002	0,004	0,004	0,006	0,009	0,010	0,014
		Dinars (Dz)	0,315	0,451	0,496	0,677	1,015	1,128	1,579
	COP= 1,4	ϕb (KWh)	0,01	0,014	0,015	0,021	0,03	0,035	0,05
		Euro (€)	0,001	0,002	0,002	0,003	0,005	0,005	0,008
		Dinars (DZ)	0,180	0,257	0,283	0,386	0,580	0,644	0,902

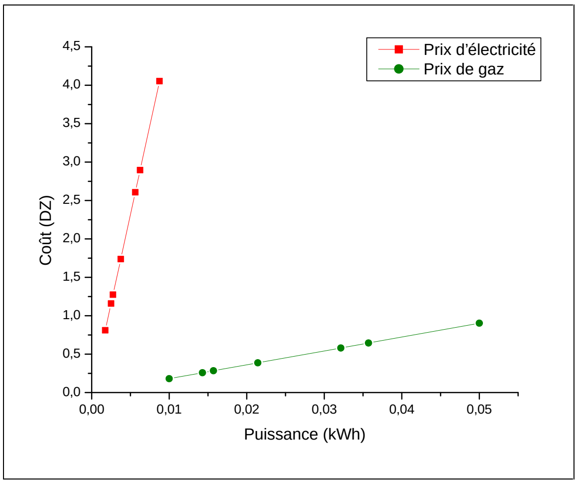

Fig.8. Cost of producing the cold

Figure 8 presents a comparison between the cost of consumption between electricity and natural gas, it can be seen that the cost of producing the cold, using absorption refrigeration systems (the heat supplied to the boiler by natural gas) is lower than the mechanical compression system using propane as a fluid Refrigerant (consumption of electricity), especially.

5. CONCLUSION

Peak electricity costs considerably more than in the off-peak period. Moving peak-hour consumption to less-busy hours, thanks to ice storage, results in operating savings that can be significant,and the results show that cold storage plays an important role in reducing energy consumption in local areas.

The results show that the consumption of electrical energy is influenced by the heat inputs of the room, that is to say that the consumption increases with the importance of the calorific loads (dimensions, orientation, insulation, geographical place).

It is found that the cost of energy consumption increases with the increase of power by the compressor, and after the comparison between the cost of electric energy without cold storage and the results shows that the cost of electrical energy with Storage is significantly lower than that without storage therefore the cold storage can participate in reducing the consumption of electrical energy in air conditioning in the building sector.

1. Reduction in the size of refrigeration equipment However, an energy performance and lifecycle impact assessment is imperative to avoid performance bottlenecks.
2. Replace the mechanical compression by a thermal compression; an absorption refrigeration machine using solar energy especially in the south of Algeria is more economical compared to the electrical energy by the mechanical compressor.

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