REFRIGERATION BY USING COAL BRIQUET AS AN ALTERNATIVE ENERGY[1)]

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ABSTRACT

This paper describes experimental studies of ammonia/water absorption refrigeration cycle, which uses coal briquet as the main energy source. In the range of experiments, it is found that the COP of the system is about 0.3, while the cooling time required is comparable to the conventional vapor compression refrigeration cycle. It is found that the refrigeration cycle is feasible to be developed for house hold purposes as well as in industries, although it was revealed that much effort have to be done before realizing for commercial applications.

INTRODUCTION

The policy of Indonesian government for utilizing coal briquet in the industri and household purposes is still have many constraints. One of this constraints for household purposes is its ignition difficulty as well as controlling the heat rate value. Therefore, before the design improvement of coal briquet furnace is found, we have to choose some implementation sectors which still satisfying this advantageous. One of the sector that consumed much energy is heating, refrigerating and air conditioning system. This sector promises high potential of using coal briquet as an alternatif of energy.

The phaseout of chlorofluorocarbon-based refrigerant (CFC) as mandated by the Montreal Protocol has forced the HVAC&R industry to search for alternatives either by developing new working fluids or by using existing fluids that have zero ozone depletion potential (ODP). Ammonia is a naturally occurring substance that has been used in industrial refrigeration applications since the mid-nineteenth century. Ammonia is an attractive choice as a refrigerant because it has a higher latent heat of vaporization, a

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lower density, and a lower unit cost compared to CFC. To achieve the specified refrigerating capacity, the required flow rate of ammonia will be between one-seventh and one-tenth of that required with a CFC.

Absorption cycle have several advantages that their development worthwhile, even though the dominant method for heat pumping and refrigeration involves vapor compression cycle. Absorption heat pumps and refrigerators potentially offer energy costs that are lower than electric heat pumps and gas furnaces. Another advantage of absorption machine is that that the working fluids are environmentally benign. The use of coal briquet as the driving energy reduces the demand of electricity. Therefore, the pressure on electric utilities to build new plants would be lessened, as well as diversification of energy use.

Absorption cycle-based space-conditioning are receiving renewed attention as an environmentally safe replacement for the CFC-based vapor compression cycle. One of the most promising fluid pairs for absorption systems is ammonia-water. Unlike another candidate fluid, lithium bromide-water, the NH3/H2O fluid pair has a volatile absorbent (water). Ammonia possesses numerous advantages in terms of ozone-friendliness and economy.

EXPERIMENTAL SETUP AND PROCEDURE

Figure 1 shows a schematic diagram of the overall experimental setup, which was designed in accordance to meet the function as a refrigerator and cold storage. The experimental setup is composed mainly of a coal briquet furnace, an absorber, a pump, a generator, a rectifier, a condenser, a capillary tube, and two evaporators. Ammonia is supplied from a reservoir to the absorber, which then distributed by the pump to the generator. A narrow window is installed to control the level of water. Detailed design of the system is given in Figure 2. Concentration of ammonia in this experiment is 42 %.

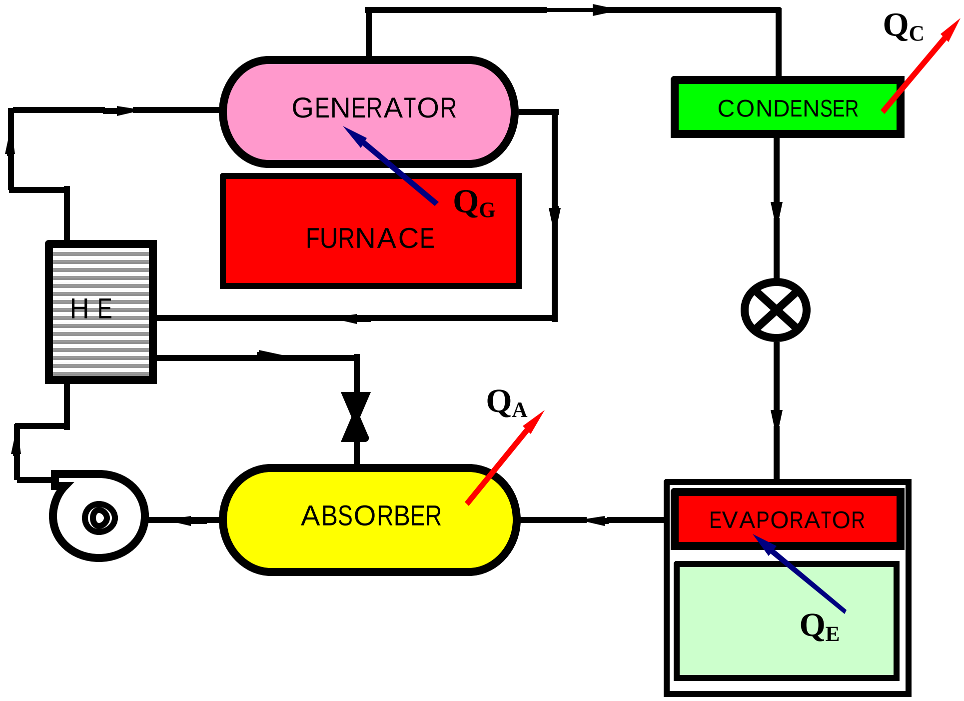

Figure 1 Schematic diagram of overall experimental setup

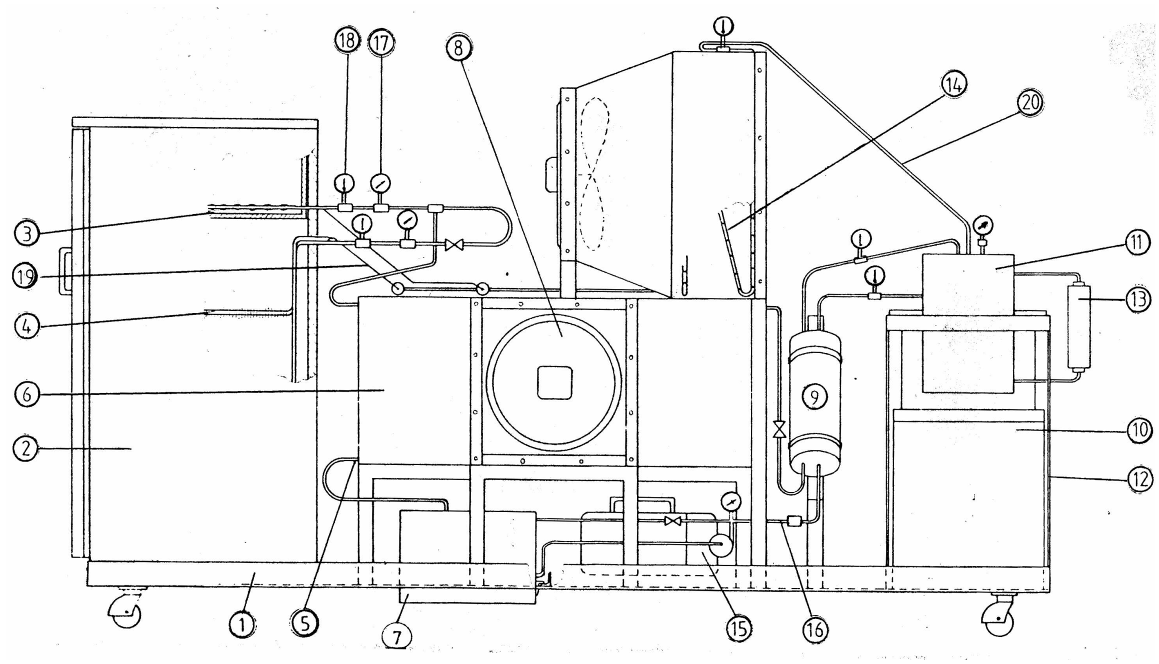

Fig. 2 Engineering drawing of refrigeration unit

Legend of Fig. 2

1. Frame	8. Absorber fan	15. Pump
2. Cool box	9. Heat Exchanger	16. Refrigerant pipe
3. Freezer evaporator	10. Furnace	17. Pressure gauge
4. Cooling chamber evaporator	11. Generator	18. Thermometer
5. Absorber	12. Generator support	19. Capillary tube
6. Absorber chamber	13. Fluid level control	20. Rectifier
7. Absorber collector	14. Condenser	

Before filling the absorber, the system should be fully evacuated. Although the system is vacuum tight, a small amount of air can leak into the system as time passes. Therefore the system is purged about five minutes before filling water and ammonia, until the vacuum pressure reached 27 – 30 in Hg. The system is firstly filled with water into the generator and the absorbent collector. The ammonia is filled up from a reservoir into the absorber, which then will solve to water to become a refrigerant solution. The filling up pressure of ammonia in this study is designed between 17 and 22 psig (the ambient temperature is 24 – 29 ^{o}C). The refrigerant pump is still run until this pressure is reached.

After the system has reached its initial steady condition, then the coal briquet furnace ready to heat the generator and begin the experiment. The geometry and physical properties of coal briquet used in this investigation are given at the end of this paper. The form of coal briquet furnace is not specially designed, but the one, which is used commercially for cooking. During the experiment it is hardly difficult to control the rate of heat transfer to the generator since there is no particular furnace meets this. The charcoal is used to initiate the combustion of this coal briquet

RESULTS AND DISCUSSION

The experimental results are presented in the Table 1. The value of heat rate transferred to the generator (Qg) is calculated from LHV of coal briquet and the time required for finishing each measurement, while Qe represents the cooling load of either the freezer or cooling chamber. COP of the system is defined as the ratio of Qe and Qg. The time required to meet the cooling load is measured after all the briquet have completely combusted. The relation between COP and the time required with respect to mass of coal briquet is depicted in the Figure 3 and Figure 4, respectively.

Table 1 Experimental Results

No.	Number of coal briquette	Mass (gr)	Qg (W)	Qe (W)	Time (min)	COP
1	5	270	482	-	268	-
2	6	324	438	-	246	-
3	7	378	618	179	144	0.29
4	8	432	636	191	135	0.30
5	9	486	673	215	120	0.32
6	10	541	847	246	105	0.29
7	12	649	1090	349	74	0.32
8	14	757	1011	273	95	0.27
8	16	865	1356	353	73	0.26
10	18	973	1695	525	49	0.31
11	20	1081	1695	559	46	0.33

From Figure 3 we can see that the COP of the system is almost constant at the value of about 0.3. The scatter of COP value probably caused by the uncertainty of measurement and inconsistency of the value of LHV. Although the average value of COP is smaller than the design value, which is 0.55, it seems to be potential to develop the more efficient equipment. This smaller value is caused by the fact that, during the experiments, we are unable to control the combustion effectively.

In the Figure 4 is shown that the larger the mass of coal briquet the faster the time required to meet the cooling loads. However, this trend does not represent the operating cost of the system. It could be useful for the purpose of one who wants to know the operating time. To calculate the operating cost more accurate, it needs another factors such as the optimum cooling load. Eventually, this cooling time seems to be comparable to the time required by the vapor compression cycle refrigerator. Therefore, in addition to the case of COP, the system also has a good reason to be developed in the future.

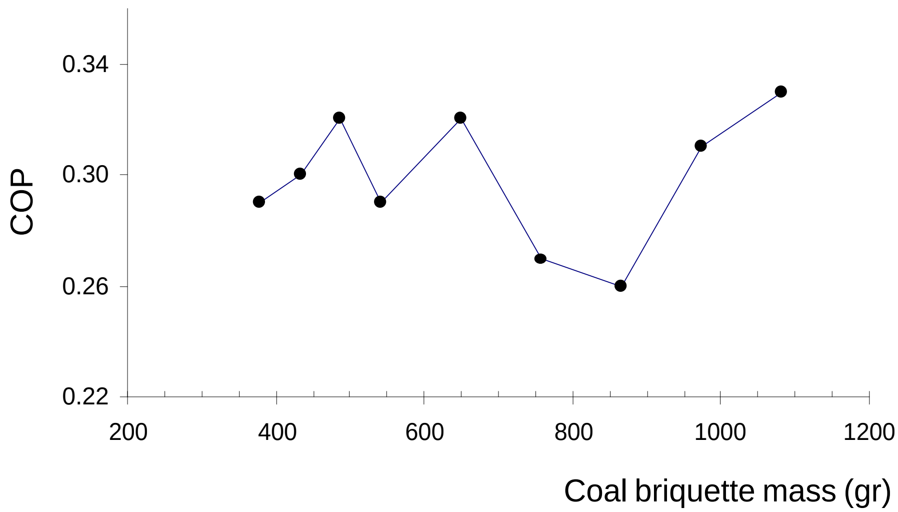

Figure 3 Effect of coal briquet mass to COP

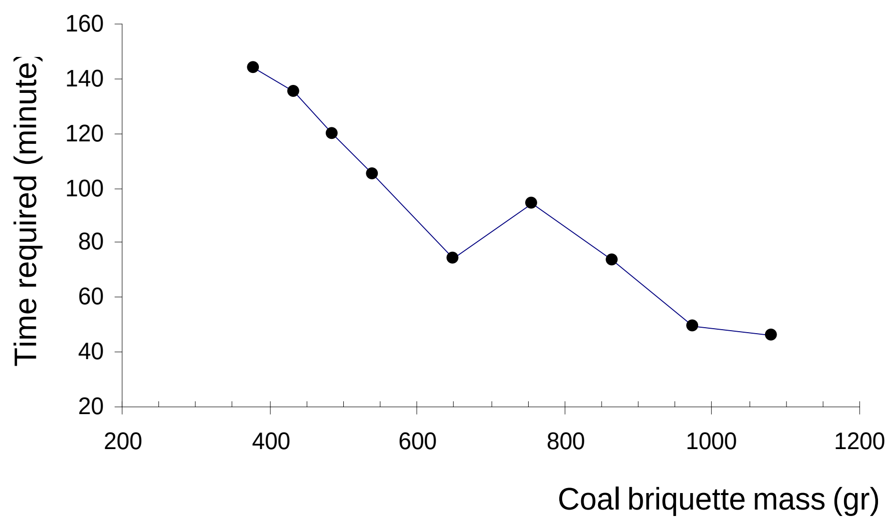

Figure 4 Influence of coal briquet mass to cooling time required

According to the overall measurement, there is a lot of work, which has to be done to improve the performance of this absorption cycle. The most important equipment, which will give very significant effect to the system, is the coal briquet furnace, in addition to either the generator or absorber. Moreover, there are also valuable to investigate the optimum weight of refrigerant and coal briquet.

CONCLUSIONS

A coal briquet absorption cycle refrigerator that is operated with ammonia/water soloution was built and its simple performances were investigated. The experimental results resulted in the following conclusions:

1. In the experimental range, the COP was found to almost in average value of 0.3
2. It was found that the cooling time is smaller when the mass of coal briquet was increased.
3. The system is feasible to be used as one according to the global issue in environment and energy diversification.

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