THE COMPARATIVE ANALYSIS HYDRIDE HEAT PUMP WITH OTHER HEAT PUMPS

Shanin Yu.I., Shanin O.I.

FSUE SRI SIA "Luch", Zheleznodorozhnaya 24, Moscow region, Podolsk, Russia, 142100
**Fax: 7+10+(4967)634582 E-mail: syi@luch.podolsk.ru*

Introduction

Development of hydride technologies remains perspective area of researches. Hydrogen application as universal and ecologically pure fuel on transport becomes justified in process of an stocks exhaustion of organic energy carriers. Storage onboard the car of hydrogen using hydride accumulator is competitive in relation to other technologies.

Use of hydrogen sorption thermal effects has opened a new scope of hydrogen technologies - working out of hydride heat engines (basically hydride heat pumps - a HHPs). In the world the wide experience of working out both laboratory, and industrial samples a HHP is accumulated. Technologically elements a HHP are fulfilled enough and during a time to ask a question: whether can be a HHP competitive in comparison with the heat pumps (HP) working on other physical effects?

Heat engines are characterized efficiency (technical aspect) and economy (promotional aspect). Heat pumps are necessary to the consumer effective, cheap and simple in service.

The purpose of the present article is to compare on known methodology a HHP to baseline heat pumps.

Methodology

For a comparison basis was the methodology stated in [1] is taken. As baseline system for comparison a HP usual vapour compression heat pump system with the electric or engine drive used in residential and commercial unitary equipment are chosen. The method is constructed on an estimation of efficiency of heat engines for each technology at a uniform set of operating conditions as well as the application of some economic assumptions to determine "commercial viability."

As the characteristic of efficiency the HP is accepted COP: *the relation of useful heat (cold) to the spent work*. The COP a HP was estimated theoretically for the accepted operating conditions in which seasonal changes of temperature for investigated territory were used. In the analysis it was supposed that gas-fired heat pumps provide heat from three sources: (1) the outdoor heat source, (2) recovered waste heat, and (3) a gas burner with an 80% efficiency.

Economic comparison was not direct comparison of alternative technology cost and baseline system, and showed a profit (or loss) to installed cost of system at the same cost of life cycle of compared systems (calculated on unit the refrigerating capacity). At the analysis a set of other simplifying assumptions also is accepted.

Results and discussion

As baseline variants are chosen two HP: 1) electrically operated HP; 2) a HP with gas use (a gas-fired boiler or the gas furnace with efficiency of 80 % for heating and the electric conditioner (var. 1) for cooling).

Electric-driven heat pump well-known is a house refrigerator with the reversible cycle. Reverse cycle Rankine is known since 1830, but is widely used in a HP since 1950 years. In such a HP are used: compressor, condenser expansion valve and evaporator; a refrigerant - R-22.

In spite of the fact that there are comparative data for many alternative heat pumping technologies will consider only a HHP in relation to HP baseline. Among a HHP two cases are considered: 1) compressor-driven metal hydride heat pump [2]; 2) HHP operated by streams of the heat-carrier [3].

In the first case [2] the compressor is located in the hydrogen line connecting reactors-sorber filled same metal hydride the compact on the basis of $LaNi_5$. The suction line of a hydrogen compressor is connected with completely charged hydrogen a reactor filled porous metal hydride "compacts". The discharge line is connected to a second discharged reactor. The refrigerant, hydrogen, is desorbed from $LaNi_5$ adsorbent at low pressure and temperature on the suction side and adsorbed on the $LaNi_5$ on the high pressure side. A three or four-way valve is used to cycle alternating hydrogen flow back and forth between the reactors. Thus hydrogen is compulsorily pumped over in a cycle by the compressor.

In the second case [3] the HHP operates on the same principle as in the previous case, but hydrogen transmission is carried out by connection of reactors-sorber to heat source with various temperature. As high-temperature hydride it is used $LaNi_5$, low-temperature hydride - $MmNi_{4.15}Fe_{0.85}$.

Results of comparison of thermodynamic efficiency a HPs are resulted in the Table1.

It is necessary to notice that available for today a HHP in most cases are commercially inaccessible and have no essential part in the market, and are available only in current R&D activity.

It is visible that compressor-driven metal hydride heat pumps can be able reach the COP, comparable to reverse Rankine cycle heat pump (thus: cooling efficiencies more low on 10 %, heating COP is approximately 70 % from COP for baseline electric HP), but they probably will be had by much higher life cycle cost because of high materials cost and the peripheral equipment (cost reduction of more than 230 $/kW it is necessary for this technology to compete with baseline electric HP).

Conclusions

At a modern condition a HHP are noncompetitive with baseline HP. It is necessary to raise COP and to reduce expenses for manufacture and service.

Reference

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2. Kim K.J., Feldman K.T., Lloyd Jr.G., and Razani A. "Compressor Driven Metal Hydride Heat Pumps," *Applied Thermal Engineering*, 1997; 17(6): 551-560.
3. Astakhov B.A., Afanasyev V.A., Bokalo S.Yu. et. al. Development of small-sized refrigerating installations based on metal hydride heat pump.- 6th NATO Int.Conf. "Hydrogen Material Science and Chemistry of Metal Hydriedes", ICHMS'99. Abstracts Book of NATO Int. Conf. Katsiveli, Yalta, Ukraine, September 02-08, 1999, p.306-307 (in English and Russian).

Table1. Calculated efficiency for heat pumps.

Cycle	Cycle Efficiency	Heating		Cooling	
		8.3°C	-8.3°C	28°C	35°C
Baseline HP # 1: electric-driven reversed Rankine cycle heat pumps [2]	COPc	4.98	3.08	5.3	3.97
	COPs	3.90	2.60	4.02	3.20
Baseline HP # 2: gas furnace / electric air conditioner [2]	COPc	-	-	-	-
	COPs	0.8	0.8	1.57	1.17
Compressor-driven metal hydride heat pump [2]	COPc	3.64	1.65	5.16	3.85
	COPs	2.75	1.44	3.54	2.87
HHP operated the heat-carrier* [3]	COPc	1.42	1.04	0.44	0.35
	COPs	-	-	-	-

Note: COPc - cycle COP theoretical, COPs - system COP theoretical.

* - In this case the COP is calculated as the relation of useful energy to the spent energy.