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A RESEARCH OF DETACHED HOUSES WITH AIR-BASED SOLAR SYSTEM INTENDED TO FULL SOLAR ENERGY USE
Part3. Study on The Performance Improvement Methods of Air-based Solar Heating/Hot-water Supply System by Simulation

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SUMMARY: In this paper, simulation models are made by measurement results and characteristics of solar heat system, and validated by comparison with measurement results. The problems and performance of existing solar heat system are examined by annual simulation. Also, the improvement methods are suggested for increasing amount of heat collection, decreasing heat loss, augmenting heat absorption and heat emission, and so on.

Keywords: air-based solar heat system, simulation, heat balance, improvement, heating and hot-water load

INTRODUCTION

In order to maximize the performance of solar heating and hot-water supply system, the study about the overall heat balance by application of elemental technologies is required. In this paper, it makes simulation models by measurement results and characteristics of solar heat system, and validates the models by comparison with measurement results. Furthermore, there are assessed the problems and performance of existing solar heat system by annual simulation, and the thermal performances of the system by changing the solar collector, methods of heat storage, heat insulation property and so on are examined. Finally, we propose the improvement suggestions to maximize the performance of system applied in the standard housing.

SIMULATION METHOD

Introduction of Simulation program

The simulation (ExTLA, Excel based Thermal Load Analysis) used this paper is the Excel-based thermal load calculation tool developed by MAE Lab of the University of Tokyo. It uses circular references and iterative calculations in Microsoft Office Excel, and calculates simultaneous equations by the Gauss-Seidel method. It has the characteristic that users can freely input the parameters and refer other results.

Simulation Conditions

The target building is the standard building which is defined energy-saving standards of Japan in 1999. It is divided into heating and non-heating spaces in the simulation model. For securing more areas of solar collector installation, the roof is set in a southward incline and the solar heat gain through the 1st floor windows is cut off on the supposition of surrounding buildings. Table 1 shows the simulation conditions to calculate annual thermal load.

Table 1. Simulation conditions

Weather Data	Expanded AMEDAS reference year(2000), Tokyo
Heating set point	20^{o}C
Heating Schedule	7：00~10：00、12：00~14：00、16：00~23：00
Tilt angle of solar collector	Latitude of Tokyo (35.4^{o})
Calculation period	Run up period: 1st Jan. ~ 30th April. Target period: 1st May. ~ 30th April.
Computation time interval	1hour
Hot water usage	450L/Day (at 40 ^{o}C)
Internal heat generation	13.26kWh/Day
Area and air volume of solar collector	Preliminary collector: 45m^{2}, Glass collector: 15m^{2} Air volume：780m^{3}/h

Simulation Modeling

In order to perform a simulation of the annual solar heat system, the calculation models such as solar collector, underground temperature, hot water storage tank, heat exchanger and so on were made based on experimental results and previous studies.

Simulation Cases

We perform to understand the performance of existing air-based solar heat system and examine the improvement effects of solar collector, insulation, heat storage, and control in the system. Table 2 shows simulation cases.

Table 2. Simulation cases

Base Case	General housing without heat collection
Case1	Existing air-based solar heat system
Case2	Change solar collector (Glass collector: Low-E glass)
Case3	Case2 + Insulation installation under the basis concrete
Case4	Case3 + Air circulation
Case5	Case 4 + Additional heat storage (water packs)
Case6	Case 4+ Additional heat storage (PET bottles)
Case7	Case 6 + hot water control change

CONCLUSION

By means of improvement suggestions, the glass of solar collector was changed over general flat glass to Low-E glass (Case2) which has less thermal loss relatively. Also, it was considered to set insulation (Case3) under the basis concrete for reducing heat loss into underground, to circulate indoor air (Case4) for increasing heat rejection from heat storage, to install the water packs (Case5) as additional heat storage, and to install the PET bottles (Case6) for increasing surface area of the additional heat storage. Moreover, by the method for increasing hot water supply usage by solar heat system, hot water supply control (Case7) was changed to use both heating and hot water supply in condition that the indoor temperature is under 23°C. The load of ultimate improvement suggestion (Case7) in this paper reduced 66.5% compared with the general housing without solar heat system, and it is even 18.2% lower than the existing air-based solar heat system.

References

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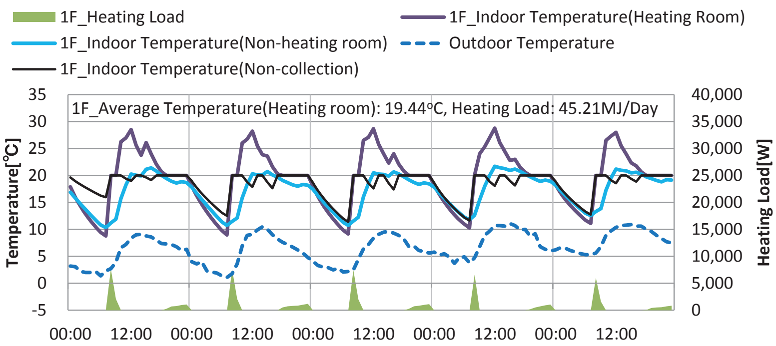

Figure1. 1F Indoor temperature and heating load of the existing air-based solar heat system (Case1, 7th ~ 11th Jan.)

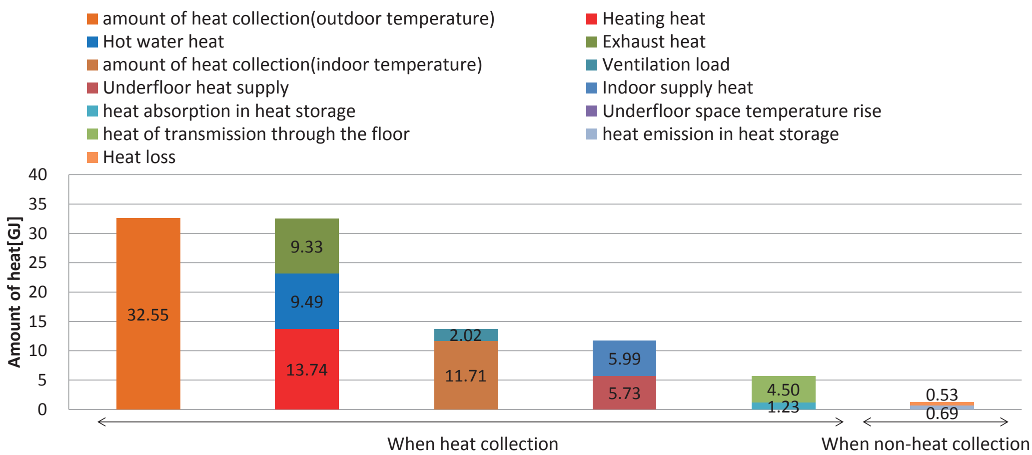

Figure2. Amount of heat of the existing air-based solar heat system (Case1, 15th Nov. ~ 30th Apr.)