Research Journal of Applied Sciences, Engineering and Technology 5(23): 5370-5376, 2013
DOI:10.19026/rjaset.5.4203
ISSN: 2040-7459; e-ISSN: 2040-7467

Submitted: September 03, 2012 Accepted: October 25, 2012 Published: May 28, 2013

**Research Article**

# Experimental Research of Variable Operating Performance on Water Source Multi-Connected Air-Conditioning System with Digital Scroll Compressor

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**Abstract:** In this study, we study the water source heat pump and digital scroll compressor and experimentally in the multi-connected air-conditioning system. Variable performance is developed when the unit operates in refrigerating and heating mode. The maximum of refrigerating capacity is 36519.95W when inlet water temperature of the condenser is 30°C and dry-bulb temperature of indoor air is 32°C, at the same time the maximum of EER is 4.33 when inlet water temperature of the condenser is 20°C and dry-bulb temperature of indoor air is 27°C. The unit operates in heating mode, the maximum of heating capacity and EER is 33275.73W and 3.86 when inlet water temperature of the condenser is 30°C and dry-bulb temperature of indoor air is 20°C.

**Keywords:** Digital scroll compressor, energy-saving, multi-package air-conditioning system

## INTRODUCTION

Nakamura and Komine (2005) considered that energy consumption of air conditioning accounts for 40-60%. Park *et al*. (2001) developed performance analysis on a multi-type inverter air conditioner. Decreasing energy consumption of air conditioning and developing highly efficient and energy-saving products are the aim of refrigerating and air conditioning technology. Multi-connected air-conditioning unit is a new type system developed under these circumstances. Nakamura and Komine (2005) study the energy saving performances of multi-package air-conditioners for commercial buildings. Park *et al*. (2001) have a research of the performance analysis on a multi-type inverter air conditioner. Xia (2005) has a research of control and optimization of VRF air system. Li *et al*. (2007) give an investigation of air conditioner performance-testing bench with enthalpy difference method. Chella *et al*. (2010) study the agent-oriented software patterns for rapid and affordable robot programming.

In this study, water source heat pump with digital scroll compressor is put forward in the multi-connected air-conditioning system and is a new type of variable refrigerant flow air conditioning system. It is combined water source air conditioning technology with multi-connected air-conditioning technology with digital scroll compressor.

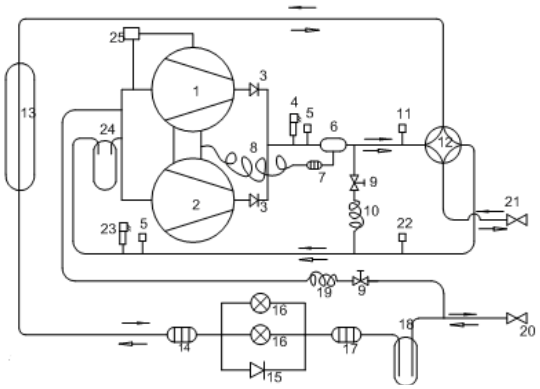


Fig. 1: Schematic of water source multi-connected air-conditioning with digital scroll compressor of outdoor unit

## SYSTEM FUNDAMENTALS

The sketch of the outdoor unit of multi-connected air-conditioning is shown in Fig. 1, the unit operates in cooling and heating mode, the operation mode of system is introduced as follows.

The prototype of water source multi-connected air-conditioning with digital scroll compressor is one-driven-four system, one outdoor unit of 32 kW refrigerating capacity is connected with four indoor units of 8 kW refrigerating capacity. The sketch of indoor unit is shown in Fig. 2.

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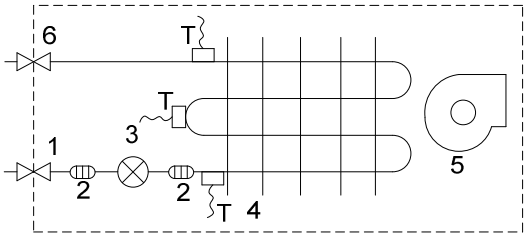


Fig. 2: Schematic of water source multi-connected air-conditioning with digital scroll compressor of indoor unit

## RESULTS AND DISCUSSION

**Experimental result in refrigerating mode:** Outdoor dry-bulb and wet-bulb temperature for performance test is 21, 15, 24, 17, 27, 19, 30, 21, 32 and 24°C, respectively, developing the inlet air parameter having effect on refrigerating performance of the unit. The inlet temperature of outdoor condenser keeps constant 30°C for the water source multi-connected air-conditioning system with digital scroll compressor; flow rate of water is 7.01 $m^3/h$.

Figure 3 shows the relationship between the refrigerating capacity and input power of the unit and the dry and wet bulb temperature of indoor. Indoor dry-bulb and wet-bulb temperature for performance test is 21, 15, 24, 17, 27, 19, 30, 21, 32, 24°C, respectively. The result indicates the refrigerating capacity and input power of the unit increases with the rise of the dry bulb temperature of indoor. It is because the evaporating temperature of the unit also gradually increased with the gradual advance of the dry bulb temperature of indoor, specific refrigerating capacity increased with the rise of the evaporating temperature, the refrigerating capacity of the unit also increased. When the dry and wet bulb temperature of indoor when indoor dry-bulb and wet-bulb temperature for performance test is 21 and 15°C respectively, the minimum of refrigerating capacity and input power of the unit is 27404.45W and 8745.7W; When the dry and wet bulb temperature of indoor for performance test is 32 and 24°C, respectively, the maximum of refrigerating capacity and input power of the unit is 36519.95W and 9211.73W.

Figure 4 shows the change of the suction and discharge temperature of compressor with the dry and wet bulb temperature of indoor air. The suction and discharge temperature of compressor keeps stable with moderate and increases with the rise of the dry and wet bulb temperature of indoor air. The rise of evaporating temperature makes suction and discharge temperature elevate. When the dry and wet bulb temperature of indoor for performance test is 32 and 24°C, respectively, the maximum of discharge temperature is 77.72°C.

Figure 5 shows the trend of temperature after evaporation of the indoor unit with the rise of dry bulb temperature for indoor air when indoor dry-bulb and wet-bulb temperature for performance test is 21, 15, 24, 17, 27, 19, 30, 21, 32 and 24°C, respectively. Temperature after evaporation of 1#, 2#, 3# and 4# increases with the rise of dry-bulb temperature of

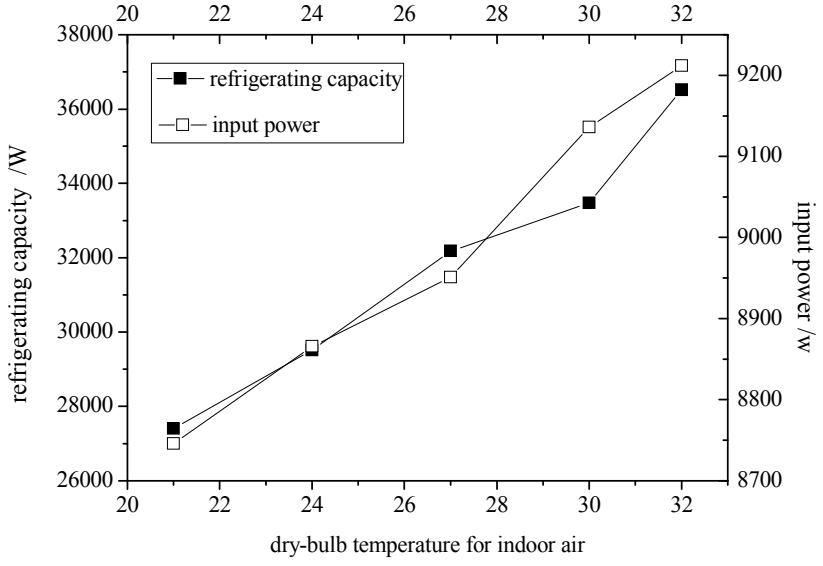


Fig. 3: The curve of refrigerating capacity and input power vs. dry bulb temperature for indoor air

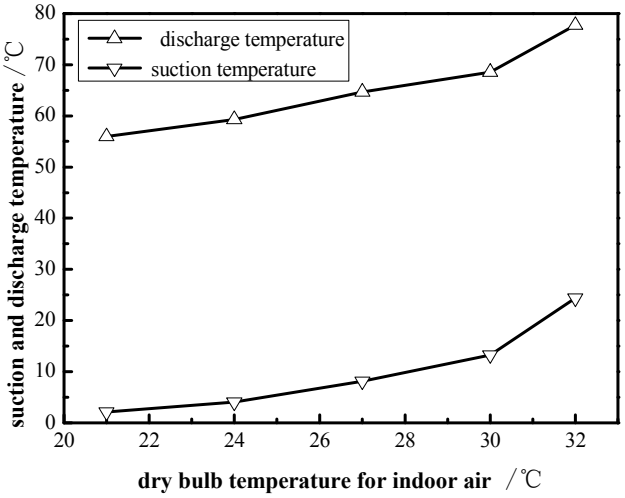


Fig. 4: The curve of suction and discharge temperature vs. dry bulb temperature for indoor air

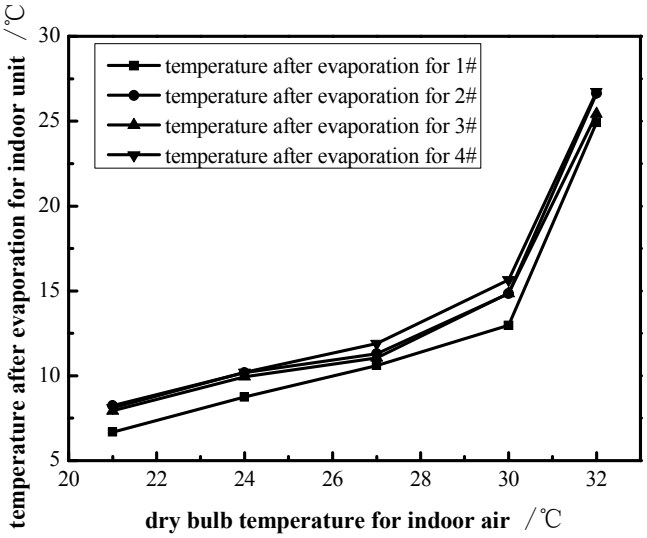


Fig. 5: The curve of temperature after evaporation vs. dry bulb temperature for indoor air

indoor air and the trend is almost same. It shows the effect of refrigerant distribution is better, the refrigerating effect of the close unit is best. At the same time, the higher output power of the compressor, the lower temperature after evaporation of the indoor unit is.

Outdoor dry-bulb and wet-bulb temperature for performance test is 21, 15, 24, 17, 27, 19, 30, 21, 32 and 24°C, respectively, developing the inlet air parameter having effect on refrigerating performance of the unit. The inlet temperature of outdoor condenser keeps constant 30°C for the water source multi-connected air-conditioning system with digital scroll compressor; flow rate of water is 7.01 m³/h.

Inlet water temperature on the side of condenser for performance test is 21, 20, 25, 30, 35 and 40°C, respectively, developing the inlet water parameter having effect on refrigerating performance of the unit. The inlet dry-bulb and wet-bulb temperature of indoor air keeps constant 27 and 19°C, respectively for the water source multi-connected air-conditioning system with digital scroll compressor; flow rate of water on the side of condenser is 7.01 m³/h.

Figure 6 shows the relationship between the refrigerating capacity and input power of the unit and inlet water temperature of outdoor condenser when inlet water temperature on the side of condenser for

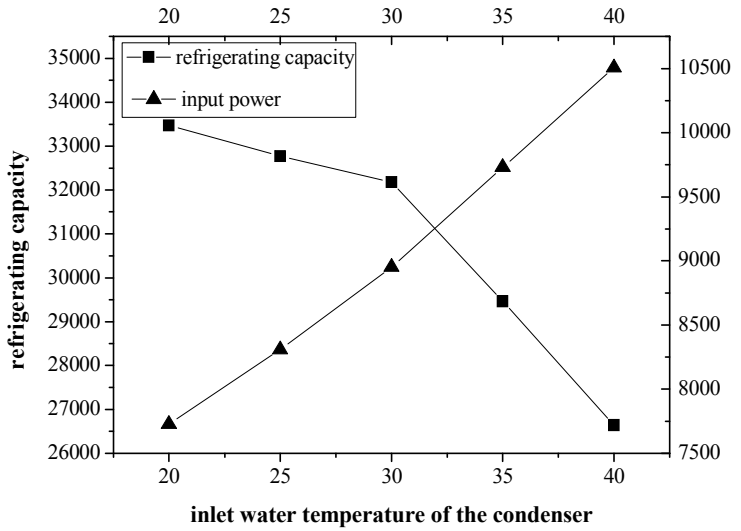


Fig. 6: The curve of refrigerating capacity and input power vs. water temperature for the condenser

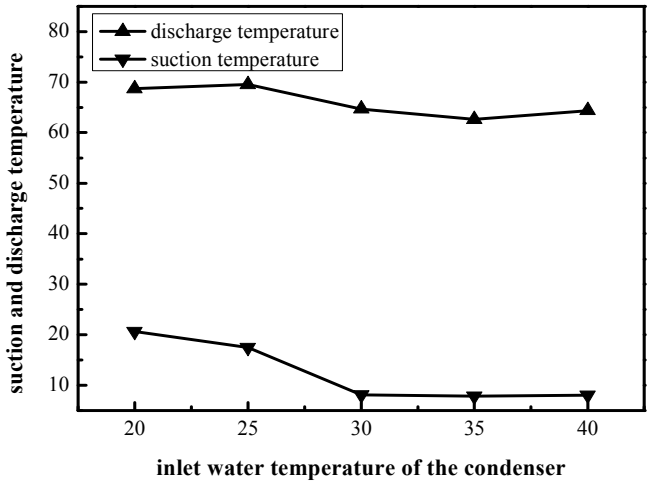


Fig. 7: The curve of suction and discharge temperature vs. inlet water temperature for the condenser

performance test is 21, 20, 25, 30, 35 and 40°C, respectively. The result indicates the refrigerating capacity decreases with the rise of inlet water temperature of outdoor condenser. It is because the condensing temperature of the unit also gradually increased with the gradual advance of inlet water temperature of outdoor condenser, specific refrigerating capacity decreased with the rise of the condensing temperature, the refrigerating capacity of the unit also decreased. When inlet water temperature of outdoor condenser for performance test is 20°C, the maximum of refrigerating capacity of the unit is 33472.3W; when inlet water temperature of outdoor condenser for performance test is 40°C, the minimum of refrigerating capacity of the unit is 26639.17W. Input power of the unit increases with the rise of inlet water temperature of outdoor condenser, when inlet water temperature of outdoor condenser for performance test is 20°C, the minimum of input power of the unit is 7726.97W; when inlet water temperature of outdoor condenser for performance test is 40°C, the maximum of input power of the unit is 10506.53W.

Figure 7 shows the change of the suction and discharge temperature of compressor with inlet water temperature of outdoor condenser. The variation of suction and discharge temperature had the same tendency hereabout. The suction and discharge temperature of compressor keeps stable with moderate

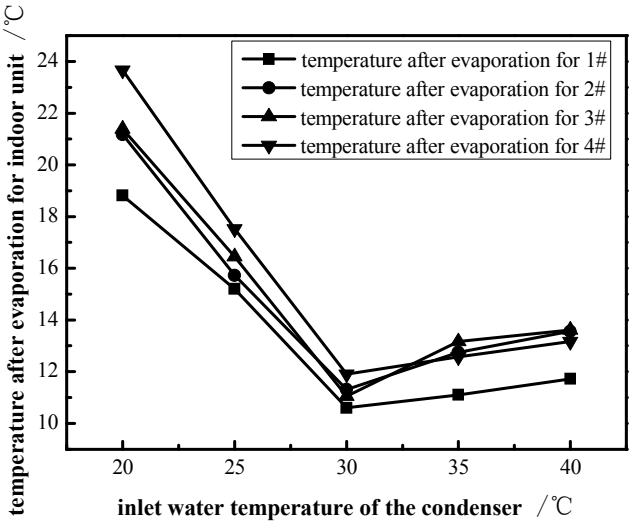


Fig. 8: The curve of temperature after evaporation for indoor unit vs. inlet water temperature for the condenser

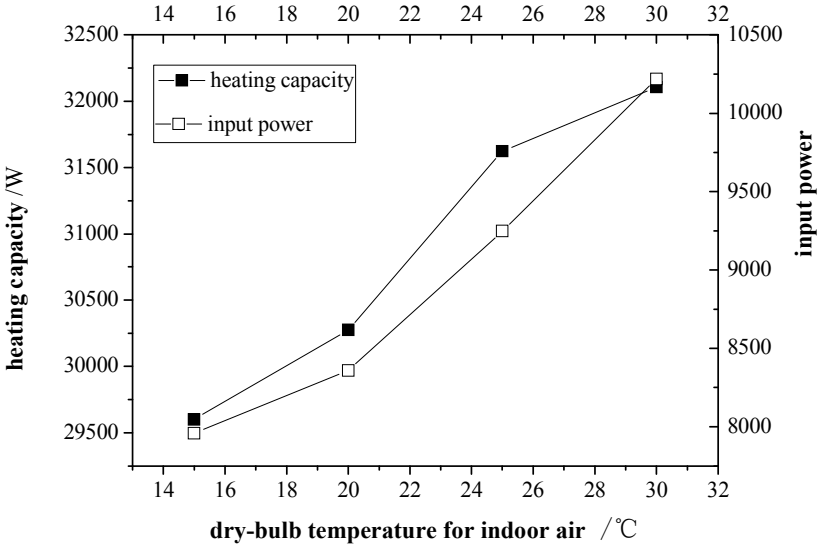


Fig. 9: The curve of heating capacity and input power vs. dry bulb temperature for indoor air

and decreases with inlet water temperature of the condenser. Discharge temperature of the compressor is fluctuant 65°C. Figure 8 shows the curve of temperature after evaporation for indoor unit vs. inlet water temperature for the condenser.

**Experimental result in heating mode:** Outdoor dry-bulb temperature for performance test is 15, 20, 25 and 30°C, respectively, developing the inlet air parameter having effect on heating performance of the unit. The inlet temperature of outdoor condenser keeps constant 20°C for the water source multi-connected air-conditioning system with digital scroll compressor; flow rate of water is 7.01 m³/h.

Figure 9 shows the relationship between the heating capacity and input power of the unit and the dry bulb temperature of indoor air. The result indicates the heating capacity and input power of the unit increases with the rise of the dry bulb temperature of indoor air. It is because the condensing temperature of the unit also gradually increased with the gradual advance of the dry bulb temperature of indoor air, specific heating capacity increased with the rise of the condensing temperature, the heating capacity of the unit also increased. When the

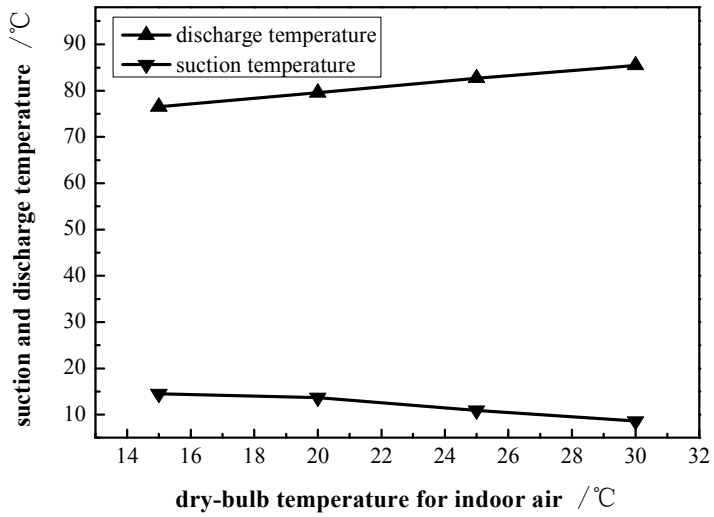


Fig. 10: The curve of suction and discharge temperature vs. dry bulb temperature for indoor air

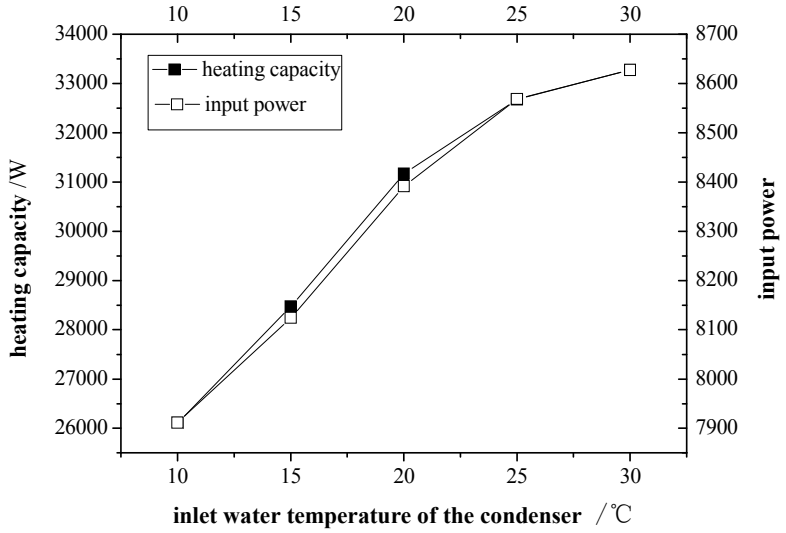


Fig. 11: The curve of heating capacity and input power vs. water temperature for the condenser

dry bulb temperature of indoor air for performance test is 15°C, the minimum of heating capacity and input power of the unit is 29601.42W and 7958.7W; when the dry bulb temperature of indoor air for performance test is 30°C, the maximum of heating capacity and input power of the unit is 32948.91W and 10219.22W.

Figure 10 shows the change of the suction and discharge temperature of compressor with the dry bulb temperature of indoor air. The suction and discharge temperature of compressor keeps stable within normal range and the discharge temperature increases slowly with the rise of the dry bulb temperature of indoor air. The suction temperature decreases slowly with the rise of the dry bulb temperature of indoor air.

Figure 11 shows the relationship between the heating capacity and input power of the unit and inlet water temperature of outdoor condenser when inlet water temperature on the side of condenser for performance test is 10, 15, 20, 25 and 30°C, respectively. The result indicates the heating capacity and input power of the unit increases with the rise of inlet water temperature of outdoor condenser. When inlet water temperature of outdoor condenser for performance test is 10°C, the minimum of heating

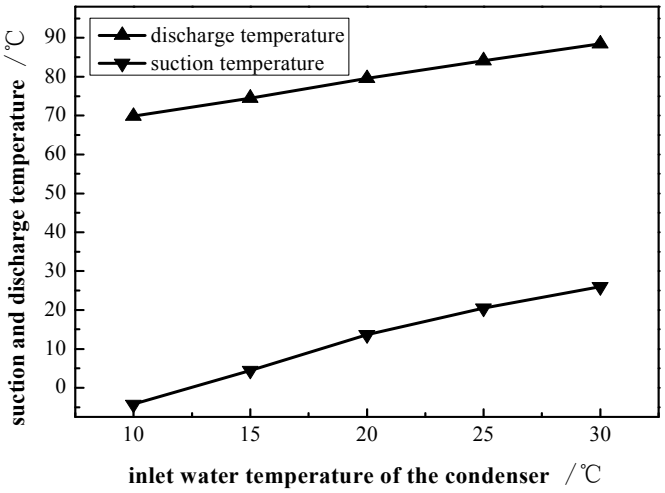


Fig. 12: The curve of suction and discharge temperature vs. Intel water temperature for the condenser

capacity and input power of the unit is 26108.12W and 7911.63W; when inlet water temperature of outdoor condenser for performance test is 30°C, the maximum of refrigerating capacity and input power of the unit is 33275.73W and 8627.47W.

Figure 12 shows the change of the suction and discharge temperature of compressor with inlet water temperature of outdoor condenser. The suction and discharge temperature of compressor increases with the rise of inlet water temperature of outdoor condenser and they are within the admission range.

## CONCLUSION

Water source heat pump and digital scroll compressor are used and experimentally studied in the multi-connected air-conditioning system in this study. Variable performance is developed when the unit operates in refrigerating and heating mode. The maximum of refrigerating capacity is 36519.95W when inlet water temperature of the condenser is 30°C and dry-bulb temperature of indoor air is 32°C, at the same time the maximum of EER is 4.33 when inlet water temperature of the condenser is 20°C and dry-bulb temperature of indoor air is 27°C. The unit operates in heating mode, The maximum of heating capacity and EER is 33275.73W and 3.86 when inlet water temperature of the condenser is 30°C and dry-bulb temperature of indoor air is 20°C.

## ACKNOWLEDGMENT

The authors wish to thank the helpful comments and suggestions from my teachers and colleagues. Project (No. 21076200 and No. 0611010100) supported by National Natural Science Foundation of China and Department of Science and Technology of Henan Province.

## REFERENCES

Chella, A., C. Massimo and G. Salvatore, 2010. Agent-oriented software patterns for rapid and affordable robot programming. J. Syst. Software, 83(4): 557-573.

Li, X.L., X.L. Cao, W. Wang, Sh.X. Yu and T. Zhao, 2007. Investigation of air conditioner performance-testing bench with enthalpy difference method. Fluid Mach., 35: 69-71.

Nakamura, T. and H. Komine, 2005. Energy saving performances of multi-package air-conditioners for commercial buildings: Investigation report on manufacture's catalogues. Transactions, 105: 43-47.

Park, Y., K. Yc and M. Mk, 2001. Performance analysis on a multi-type inverter air conditioner. Energy Conv. Manag., 42: 1607-1621.

Xia, J.X., 2005. Research of Control and Optimization of VRF Air System. Tsinghua University, Beijing.