Performance Simulation and Study Analysis of The Vehicle Air Conditioning System

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Keywords: Vehicle, air-condition, cooling system, temperature, performance

Abstract. In this paper, it is established the model of air-conditioning system and a simplified model of cooling system in the vehicle. That model is based on the test data. One-dimensional model has been corrected by the three-dimensional calculation results. Therefore, the one-dimensional model also reflects the impact of cabin air return. The results show that the coolant temperature affect on the performance of air conditioning is very small. But the ambient temperature affect on the performance of air conditioning is significant.

Model

The performance of air conditioning system is not only effect on the working conditions of vehicle it is also influenced by the cooling system. Therefore, in this paper, it is established the model of air-conditioning system and a simplified model of cooling system in the vehicle. Wherein air conditioning system is consist of a compressor model, a condenser model, model evaporator, thermostat model. That model is based on the test data shown as in Figure 1.

The actual flow of the vehicle cabin is very complex, so we have established a cabin air-side model according to the position of the vehicle front-end module. One-dimensional model has been corrected by the three-dimensional calculation results. Therefore, the one-dimensional model also reflects the impact of cabin air return shown as in Figure 2.

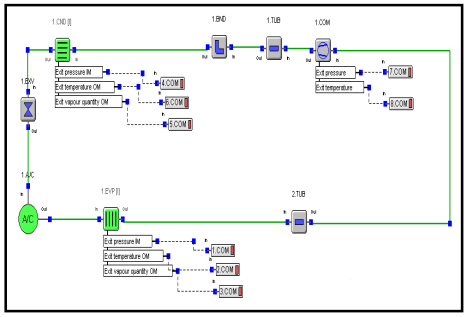

Fig1. The model of air-condition

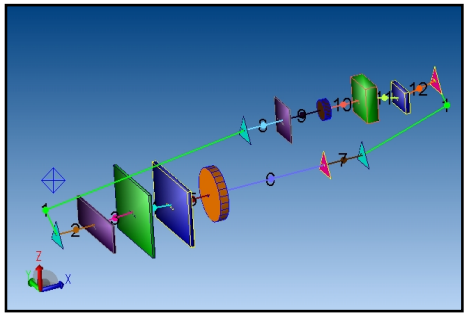

Fig2. The model of airflow

Simulation

Firstly, study the effect of different coolant temperature air conditioning system performance. Therefore, keep the ambient temperature at 35˚C, and change the engine coolant temperature at respectively is 95,105 and 115˚C, We study the performance of the air conditioning system.

Ambient temperature affect on the performance of the air conditioning system is also very important. Therefore, keep the coolant temperature at 95˚C, and change the ambient temperature respectively is 35,38 and 42˚C , We study the performance of the air conditioning system.

Table1. Simulation specifications

Name	Parameters
Speed	45km/h
Humidity	40%
Ambient temperature	35/38/42˚C
Coolant temperature	95/105/115
Air conditioning	On

Analysis

Coolant temperature affect on the air conditioning system

The results show that as the coolant temperature increases, the outlet pressure of condenser is increases. The coolant temperature at 95˚C, the outlet pressure is 15.35bar, the cooling temperature at 115˚C, the outlet pressure is 15.53bar, increased by 1.17%. From the results, the coolant temperature affect on the outlet pressure little shown as in Figure 3.

The results show that with coolant temperature increases, the air temperature of condenser is increased. The coolant temperature at 95˚C, air temperature of the condenser is 52.29˚C, the cooling temperature at 115˚C, air temperature of the condenser is 52.89˚C, increased by 1.14%. From the results, the coolant temperature affect on the air temperature of the condenser little shown as in Figure 4.

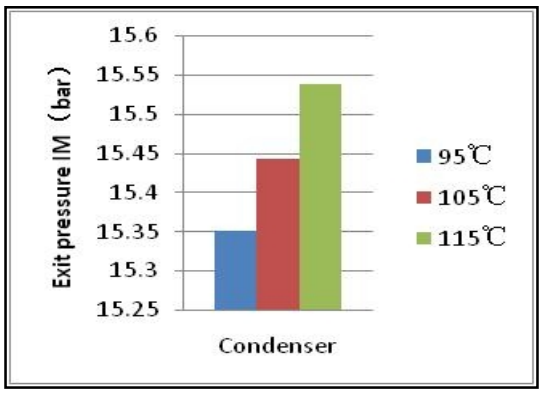

Fig3. The pressure of condenser

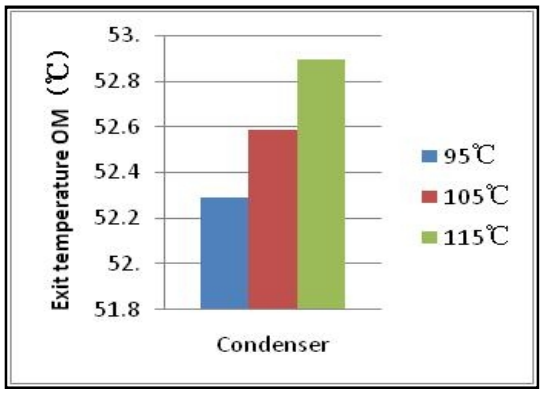

Fig4. The temperature of condenser

The results show that as the coolant temperature increases, the pressure of evaporator outlet is increasesd.The coolant temperature at 95˚C, the pressure of evaporator outlet is 3.02bar, the cooling temperature at 115˚C, the pressure of evaporator outlet is 3.04bar. From the results, the coolant temperature affect on the pressure of evaporator outlet small shown as in Figure 5.

The results show that as with coolant temperature increases, outside air temperature of the evaporator is increases. The coolant temperature at 95˚C, outside air temperature of the evaporator is 1.89˚C, the cooling temperature at 115˚C., outside air temperature of the evaporator is 1.98˚C, increased by 4.76%. From the results, the coolant temperature effect on outside air temperature of the evaporator small shown as in Figure 6.

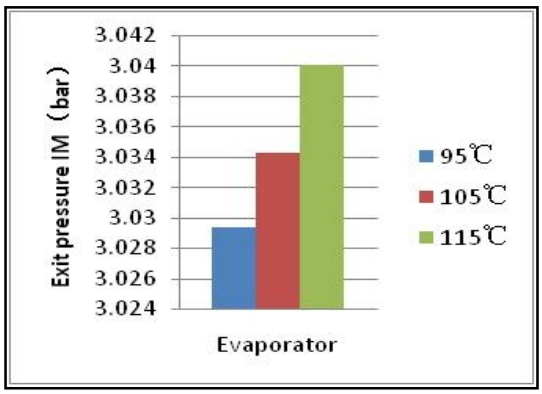

Fig5. The pressure of evaporator

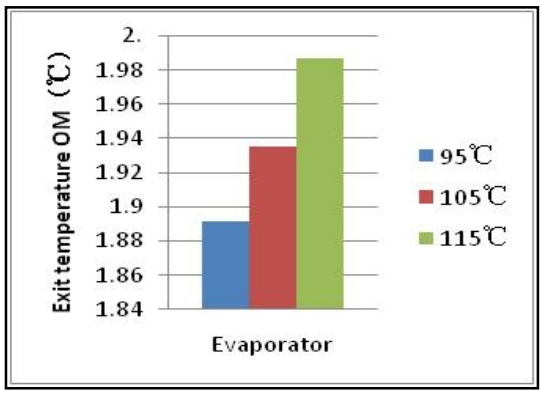

Fig6. The temperature of evaporator

As the coolant temperature increases, the outlet refrigerant temperature of the compressor rises. The coolant temperature at 95˚C, the refrigerant compressor outlet temperature is 75.51˚C, the cooling temperature at 115˚C., Refrigerant outlet temperature of the compressor is 75.96˚C. From the results, the coolant temperature affect on the refrigerant outlet temperature of the compressor small shown as in Figure 7.

As the coolant temperature increases, the COP coefficient does not affect on the air-conditioning system. In the coolant temperature is from 95 to 115˚C when, the COP coefficient of air-conditioning systems is about 1.253. Therefore, the coolant temperature had no effect on the COP coefficient shown as in Figure 8.

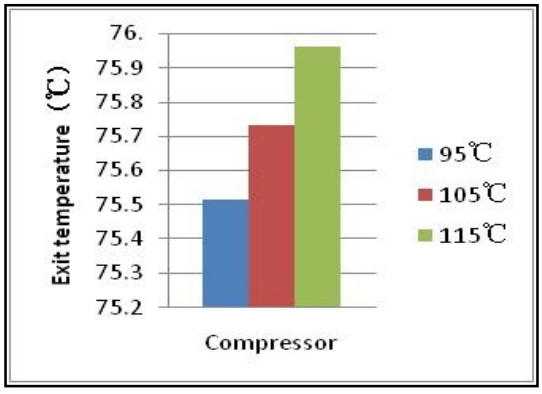

Fig7. The temperature of compressor

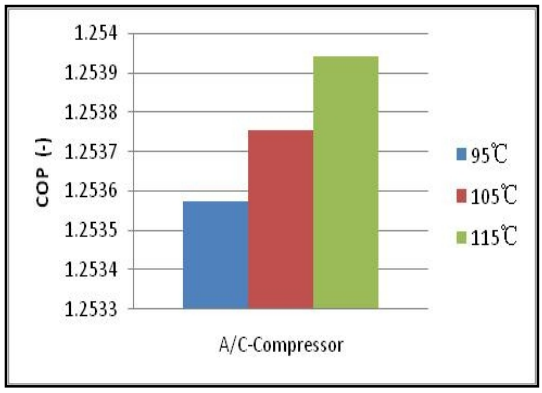

Fig8. The COP of A/C

Ambient temperature affect on the air conditioning system

When the coolant temperature kept at 95˚C, as the ambient temperature increases, the outlet pressure of the condenser is rises. The ambient temperature at 35˚C, the outlet pressure of the condenser is 15.35bar, the ambient temperature at 42˚C, the outlet pressure of the condenser is 19.38bar which is increased by 26%. From the results, the ambient temperature affect on the outlet pressure condenser large shown as in Figure 9.

As the ambient temperature increases, the outside air temperature of the condenser is increases. The ambient temperature at 35˚C, the outside air temperature of the condenser is 52.29˚C, the ambient temperature at 42˚C, the outside air temperature of the condenser is 62.39˚C, increased by 19%. From the calculated results, ambient temperature affect on the outside air temperature of the condenser obvious shown as in Figure 10.

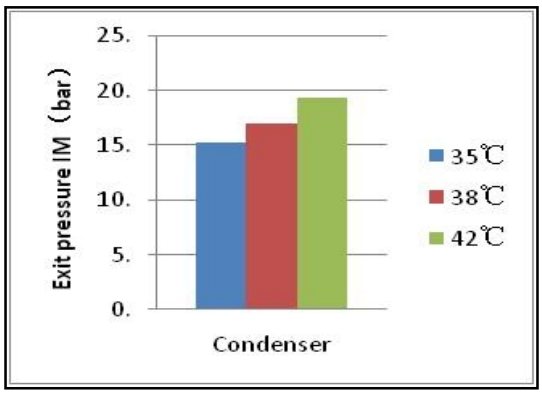

Fig9. The pressure of condenser

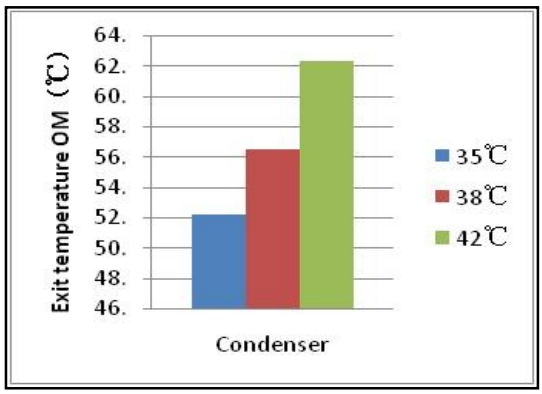

Fig10. The temperature of condenser

As the ambient temperature increases, the internal pressure of the evaporator is increases. The ambient temperature at 35˚C, the internal pressure of the evaporator is 3.02bar, the ambient temperature at 42˚C, the internal pressure of the evaporator is 3.82bar, increased by 26%. From the results, the ambient temperature affect on the internal pressure of the evaporator obvious shown as in Figure 11.

As the ambient temperature increases, the air temperature outside of the evaporator is increases. The ambient temperature at 35˚C, the air temperature outside is 1.89˚C, the ambient temperature at 42˚C, the air temperature outside is 8.62˚C, increased by 3.5 times. From the results, ambient temperature affect on the air temperature outside of the evaporator is very obvious shown as in Figure 12.

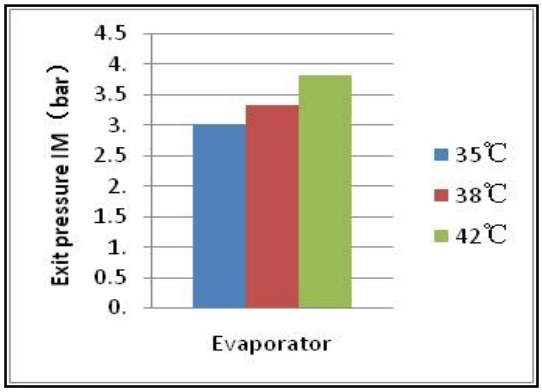

Fig11. The pressure of evaporator

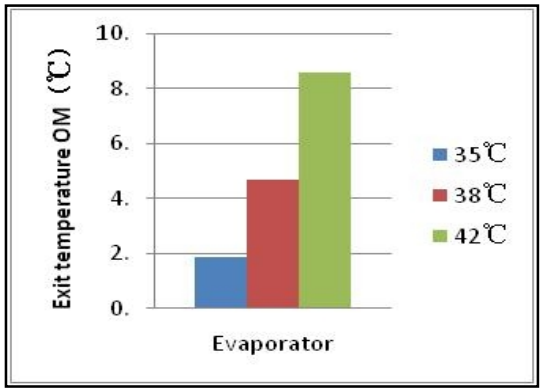

Fig12. The temperature of evaportor

As the ambient temperature increases, the refrigerant temperature of the compressor rises. The ambient temperature at 35˚C, the outlet temperature of the refrigerant compressor is 75.51˚C, the ambient temperature at 42˚C, the outlet temperature of the refrigerant compressor is 75.96˚C. From the results, the ambient temperature affect on the outlet temperature of the refrigerant compressor is small shown as in Figure 13-14.

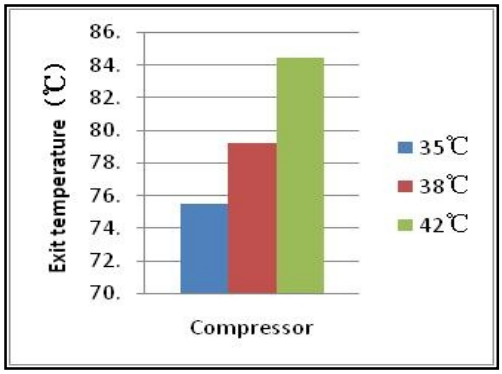

Fig13. The temperature of compressor

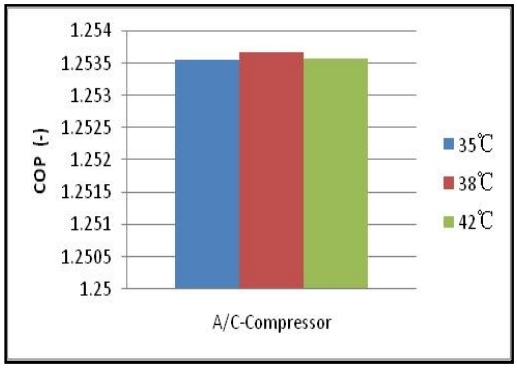

Fig14. The COP of A/C

Conclusion

1. When the engine coolant temperature at 95, 115˚C, the ambient temperature constant at 35˚C. The impact on the air conditioning compressor, condenser and evaporator performance cooling system operating temperature is very small, air-conditioned COP coefficient basically unchanged.
2. When the ambient temperature of the vehicle at 35, 38 and 42 ˚C, engine coolant temperature constant. Environmental factors on the air conditioning compressor, condenser and evaporator performance impact is significant, particularly the evaporator air outlet temperature was increased to 1.89 ˚C and 8.62 ˚C, temperature has increased by 3.5 times.
3. The air conditioning system designed to take into account the temperature field inside the cabin, engine compartment inside the vehicle at higher air temperature, the air-conditioning system cooling performance greatly.

References

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