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Experimental comparison of electronic and thermostatic expansion valves performances in an air conditioning plant

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ARTICLE INFO

Article history:
Received 7 February 2007
Received in revised form
22 August 2007
Accepted 15 September 2007
Published online 29 September 2007

Keywords:
Refrigeration system
Air conditioning
Thermostatic expansion valve
Electronic expansion valve
Experiment
Measurement
Comparison

ABSTRACT

Adopting electronic expansion valves in air conditioners enables an appreciable energy saving with respect to the same installations equipped with traditional thermostatic expansion valves. This is due to the fact that electronic valves allow a lower condensation pressure in systems equipped with air cooled condensers, which is adjusted to variations in outside air temperature. Furthermore, PID (Proportional–Integral–Derivative) control over the superheating leads to the best use of evaporator under every condition (lower superheating level of the vapour refrigerant), thus increasing the refrigerating capacity.
This paper reports on the results of a set of measurements that were carried out from March to November 2006 on the operation of eight direct expansion air conditioners having a total cooling capacity of 120 kW installed at a telephone control room near Bologna (North Italy). Air conditioners are equipped with both thermostatic and electronic expansion valves, alternatively activated by solenoid valves on a daily basis, in order to compare the two systems in the same environment and at similar load conditions. The annual analysis is supplemented by a transient simulation program to simulate the behaviour of the system in the two different operating modes in different European climates, in order to evaluate the energetic and economic advantages of electronic valve.

Comparaison expérimentale des performances des détendeurs électroniques et thermostatiques dans une installation de conditionnement d'air

Mots clés : Système frigorifique ; Conditionnement d'air ; Détendeur thermostatique ; Détendeur électronique ; Expérimentation ; Mesure ; Comparaison

1. Introduction

All refrigerating machines, both for air conditioning and refrigerating applications, have widely used thermostatic expansion valve (TEV). Though this is a useful expansion device, it reveals some characteristics that can limit versatility and performance of the machines. Some kinds of plants are more sensitive to negative aspects of TEV regulation, because

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0140-7007/$ – see front matter © 2007 Elsevier Ltd and IIR. All rights reserved.
doi:10.1016/j.ijrefrig.2007.09.004

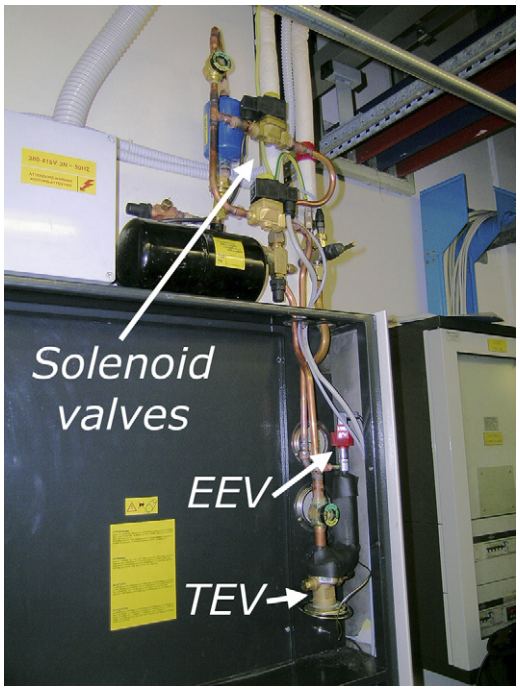

Fig. 1 – Retrofit of one air conditioner at the installation control room at Bologna site.

of plant specifics, kind of duty or distribution of cooling load during the year.

One solution to solve almost all these problems is to use the electronic expansion valve (EEV). This electrically driven control device has been widely available on the market for many years; EEV controls the refrigerant flow through the evaporator by means of monitoring pressure and temperature at the outlet of the evaporator. The two signals are elaborated by a regulator that controls, in real time mode, the opening of the valve.

The EEV application in an air conditioning plant of a telephone large control room located near Bologna in North Italy is analysed in this paper. The plant has been retrofitted with the EEV installed in parallel to the TEV, in order to operate the plant alternatively with the both technologies. A simulation model using AA.VV. (2004) has been developed to compare both technologies from the annual energetic and economic point of view under different conditions. The comparison has been made for several European countries with different climates (AA.VV. 1985). The behaviour of the innovative system was investigated via varying both the condensation conditions and the cooling loads of the control room.

Table 2 – Electrical consumptions and savings during the survey period

Period	Hourly mean electrical power		Energy saving $(C_{TEV} - C_{EEV})/C_{TEV}$ (%)
	EEV-controller (kW)	TEV–PLC (kW)	
11/03/06–17/03/06	17.8	27.1	**34.3**
02/04/06–08/04/06	21.6	29.3	26.4
15/04/06–21/04/06	23.1	29.2	20.9
11/05/06–17/05/06	23.3	29.5	21.3
22/06/06–28/06/06	32.7	35.8	**8.6**
04/07/06–10/07/06	28.4	32.9	13.8

2. Description of the plant

The control room needs to be cooled all over the year, due to the high internal power gain of the telephone equipment (50 kW + 1.5 kW lighting). The air temperature is controlled by eight direct expansion air conditioners working with refrigerant R22 and having a total cooling capacity of 120 kW. The conditioners are equipped with TEV technology and hermetic compressors. Condensation pressure is regulated by cut phase speed controllers that control fans' rotation speed. The air conditioners are operated by an external Programmable Logic Controller (PLC) with the logic described later on.

EEV system consists of

- EEVs with step-by-step DC motor;
- the driver controlling the level of superheat and the valve position by PID logic; the control is realized by monitoring the pressure and the temperature at the evaporator outlet, in such a way that the maximum efficiency of the evaporator is guaranteed;
- the controller that continuously monitors the condensing pressure within the circuit, communicates with the cut phase speed controllers' modules, and measures the electricity consumption and the cooling capacity of the air conditioners. This controller also manages the switch between both expansion valve technologies. The controller is connected to the supervisor for monitoring and setting the unit parameters from a remote place.

This retrofit solution has required creation of two parallel expansion lines, one with the TEV and one with the EEV, in the eight cooling circuits. The TEV and the EEV have been activated alternately by solenoid valves in daily regime (Fig. 1). This

Table 1 – Operation of the air conditioning plant with TEV and the PLC

	Band	No. of compressors ON	No. of evaporator fans ON	Set – Dead band (°C)	Conditions of the band run
Conditioners always ON	0	2	2 Always	–	Always ON
Regulation bands	1	3	3 Always	29 – 1	Band compressors ON
	2	2	2 Always	30.5 – 1.5	if $t_{amb} > t_{set}$
Alarm band	3	1	1 If necessary	31.5 – 1	Band compressors OFF if $t_{amb} < t_{set} - \Delta t$
Fault band	Maintenance staff in place within 1 h			34	Staff intervention