

Next-generation Ejector Cycle for Truck-transport Refrigerator

Etsuhisa Yamada, Haruyuki Nishijima, Hideya Matsui,
Toshio Ueno, Masami Taniguchi and Akira Fujita
DENSO Corporation

Copyright © 2009 SAE International

ABSTRACT

The development of energy-saving technologies is in great demand recently to stop global warming. We are committed to developing the Ejector Cycle as an energy-saving technology for refrigerating air conditioners. The ejector, which is an energy-saving technological innovation, improves the efficiency of the refrigeration cycle by effectively using the expansion energy that is lost in the conventional steam-compression cycle, and is applicable to almost all steam-compression refrigerating air conditioners, thus improving the efficiency of the refrigeration cycle. Concerning the application of the Ejector Cycle in truck-transport refrigerators, we previously released Ejector Cycle products for large and medium-size freezer trucks, which have been favorably accepted by customers.

We attempted to develop a new Ejector Cycle for application in compact refrigerators, and succeeded in completing a commercial compact refrigerator incorporating a next-generation Ejector Cycle that substantially improves performance. This paper introduces the development.

INTRODUCTION

Compact freezer trucks are used to transport frozen food. Their storage is cooled by a refrigerator, which is installed in the storage unit. The illustration shows the new refrigerator equipped with the newly developed next-generation Ejector Cycle (EJECS II), along with a diagram that shows its excellent performance (Fig.1).

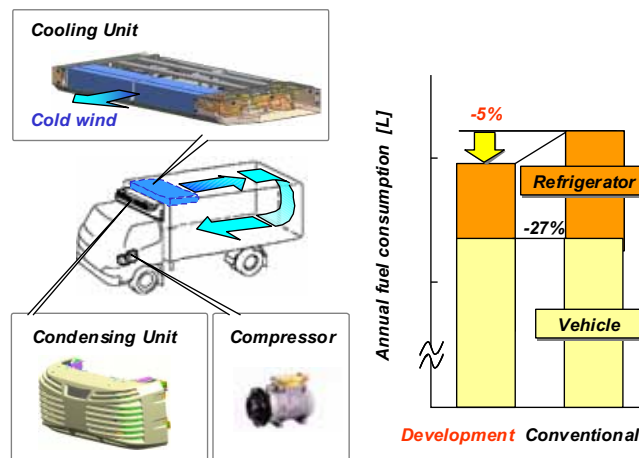


Fig.1 Overview of developed refrigerator

The new refrigerator consists of a compressor, which is driven by the truck engine as is the air conditioner, and a cooling unit and condensing unit. The cooling unit, which is only 125 mm in height, houses an ejector. This next-generation Ejector Cycle can save compressor power by approximately 27% a year (compared with our conventional refrigerators), which makes it possible to reduce the annual fuel consumption by approximately 5% in the case of a two-ton-class freezer truck (in comparison with a conventional refrigerator used for the same transportation route in Japan).

As mentioned at the beginning of this paper, we developed the world's first commercial Ejector Cycle refrigerator in 2003. To explain the difference between the conventional Ejector Cycle (EJECS I) and next-generation Ejector Cycle (EJECS II), we start with the explanation of the conventional EJECS I.

1. REFRIGERATOR EJECs I

Fig.2 shows an overview of the refrigerator for heavy-duty freezer truck, using Ejector Cycle (EJECs I). The functional components that comprise the refrigeration cycle are installed above the driver's cabin in the form of a single unit.

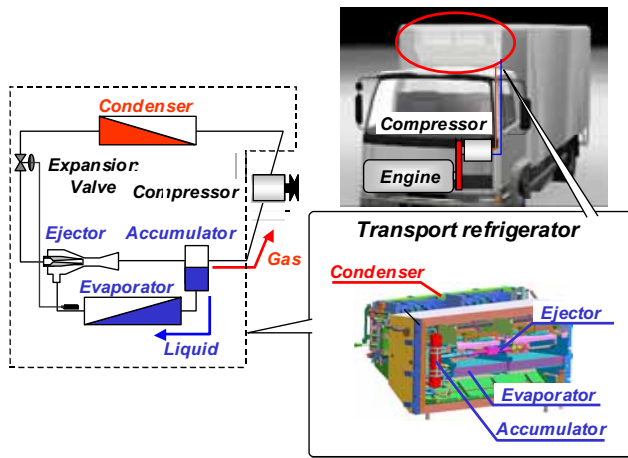


Fig.2 Ejector Cycle refrigerator for heavy-duty freezer trucks

The Ejector Cycle refrigerator for heavy-duty freezer trucks is equipped with EJECs I, in which an ejector recovers the expansion-lost energy (Δh_{eje}), which is dissipated at the time of refrigerant pressure decrease, into compressor power (Fig.3).

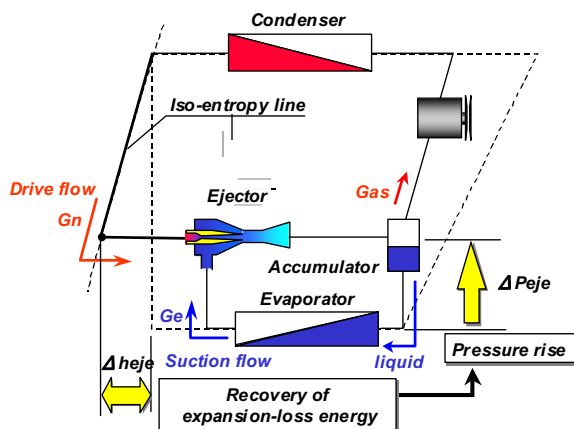


Fig.3 Recovery of expansion-loss energy by means of the EJECs I ejector

The improvement in the coefficient of performance (COP) by EJECs I is realized by the following effects (Fig. 4; in comparison with our conventional refrigerators).

1. Saved compressor power realized by ejector-increased pressure
2. Reduced evaporator-pressure loss
3. Compressor efficiency increase due to decrease of compression ratio

Condition:
Ambient temp. 35 deg C, Inside temp. -18 deg C,
At the same freezing capacity compared with expansion valve system

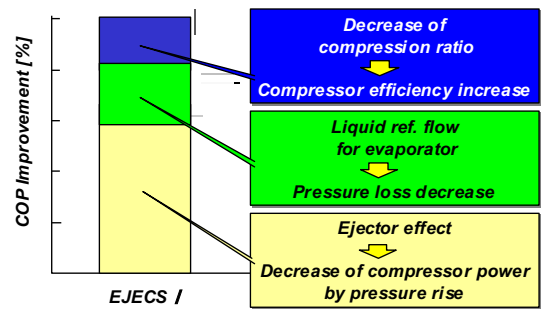


Fig.4 Principle of COP improvement

2. NEXT-GENERATION EJECTOR CYCLE SYSTEM (EJECs II)

EJECs I, which has an accumulator at the ejector outlet, could not be installed in the refrigerator unit of compact freezer trucks, because of installation space restrictions. The accumulator operates as a liquid reservoir at low-pressure side and distributes driving flow (gas) and suction flow (liquid) separately at low pressure. We therefore studied the possibility of providing liquid-reservoir function and refrigerant distributor at high-pressure side (Fig.5).

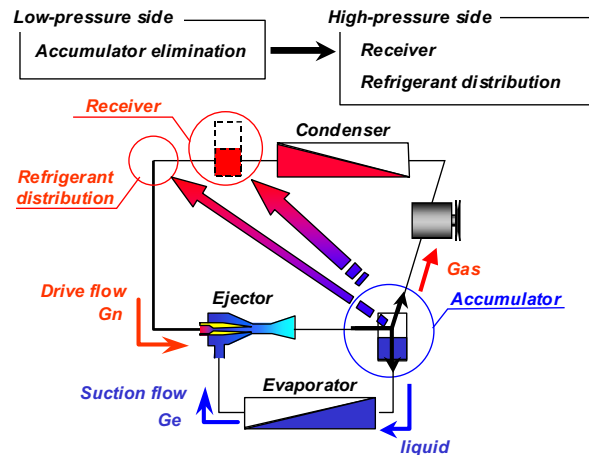


Fig.5 Ideas for developing next-generation Ejector Cycle

Fig.6 shows the construction of the new Ejector Cycle. Compared with EJECs I, the special features of the new Ejector Cycle are that no accumulator is provided and that a receiver is provided along with an intermediate-pressure refrigerant-separating point. Another special feature is that the evaporator is divided into two parts, one installed on the ejector suction end as in EJECs I, the other installed at the ejector outlet.