Received: 6 September 2017 | Revised: 9 November 2017 | Accepted: 13 November 2017
DOI: 10.1111/jfpe.12662

ORIGINAL ARTICLE

WILEY Journal of Food Process Engineering

Computational fluid dynamic study of thermal effects of open doors of refrigerated vehicles

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Funding information
National Key R&D Program of China, Grant/Award Number: 2016YFD0401205; R&D Innovation Platform Program of Beijing Academy of Agriculture and Forestry Sciences, Grant/Award Number: KYCXPT201723

Abstract
In this work, we use computational fluid dynamics (CFD) models to compare the advantages and disadvantages of various door geometries by looking at how open doors of four different door geometries affect the stability of the temperature inside a refrigerated vehicle during unloading. The results show that, with opening D1 and D2, D3 and D4, D1, D4, the temperature increases from 4 °C to 22.34, 22.65, 20.39, and 21.32 °C after 4 min, respectively. The coefficients of temperature variation are .009, .011, .015, and .014, respectively. The volume infiltration flow rates are 2.202, 2.189, 0.983, and 0.961 m^3/s, respectively. Comparing the coefficients shows that opening the D1D2 doors does not significantly perturb the temperature of the carriage, and opening the D1 door modifies the temperature less than opening the D4 door. The maximum root-mean-square error for volume mean temperature and wind speed is 1.21 °C and 0.27 m/s, respectively.

Practical applications
In urban cold-chain delivery and distribution, the main solution to maintain temperature stability on opening the doors is to limit the number of doors and their area relative to the volume of the refrigerated vehicle. As a result, it is very important to optimize the structural design of refrigerated vehicles to reduce energy consumption, enhance temperature stability inside the refrigerated compartment, and ensure the quality and safety of the perishable food stored within. In this study, the evaluation index is used with CFD technology to study how open doors of various sizes and at different locations affect the temperature inside the refrigerated vehicle. This research provides not only a more detailed understanding of flow distribution and temperature variations inside the carriage while opening the door of a refrigerated compartment but also a reliable theoretical basis for optimizing the design of refrigerated vehicles.

1 | INTRODUCTION

With the rapid development of cold chain logistics, road refrigerated vehicles are now widely used in the transportation and distribution of fresh perishable food. Refrigerated vehicles are a vital and determining factor in preserving the quality of fresh food, and their importance cannot be overemphasized. According to the relevant statistics (Billiard, 2003; Rizet, 2006), more than one million refrigerated vehicles are used throughout the world to distribute refrigerated foods. China alone uses over 100,000 refrigerated vehicles as of 2016, and this number continues to grow at an annual rate of over 20%. Several publications have predicted that global road freight transport will grow by 2.5% a year up to the year 2030 (Demir, Bektaş, & Laporte, 2014; Li et al., 2015; Popescu & Fistung, 2015). To optimize refrigeration, many studies have quantified the temperature and quality of fresh food inside refrigerated vehicles and in refrigerated containers with limited space (Ahmed, Meade, & Medina, 2010; Chourasia & Goswami, 2007; Defraeye et al., 2016; Delele et al., 2008; Liu, Saman, & Bruno, 2012;

