UNIVERSITI PUTRA MALAYSIA

DETERMINATON OF OPTIMUM LOCATION FOR CARBON MONOXIDE DETECTORS IN CAR CABINS

HAMIDREZA GHEZAVATI

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By

HAMIDREZA GHEZAVATI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirement for the Degree of Doctor of Philosophy

June 2011

DEDICATION

This thesis is dedicated to the soul of my father who passed away recently, my paternal uncle and the uncle who died from carbon monoxide poisoning, and to my beloved family, my mother, my wife SIMIN and my son, ARMIN and daughter, AZIN who always understand and give me loving support.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Doctor of Philosophy

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Chairman: Associate Professor Ir Nor Mariah bt. Adam, PhD

Faculty: Engineering

There is limited study on CO concentrations exposure in car cabin in Malaysia. The specific objectives of this study are: (i) to determine the entry routes of CO in a stationary car (ii) to determine entry for moving car on congested, less congested and not congested roads (iii) for use results from objective (i) and (ii) as input parameters on computational fluid dynamics (CFD) to predict optimum location of detector. The car was driven with different modes of air conditioning: recirculation and fresh air intake at two different times of day (morning and evening) from September through December 2008. The CFD simulations using the realizable k-ε model was used to predict optimum location of detector in car cabin. The simulation result was then verified via experimental data from literature. The k-ε model is the most common turbulent model due to its accuracy for this type of conditions.

More than 84 percent of CO entry into car cabin was through the vent in the rear trunk and through the diffuser of the air-conditioning system; i.e. 16 percent cabin

leak cracks, holes, gaps or other openings in the car cabin. The highest mean CO exposure was experienced for the recirculation mode, location Middle Ring Road II (MRRII), and time of day pm and am, with mean CO concentrations of 19.7 ppm and 18.5 ppm respectively for average of 70 trips. Experimental measurements on CO level was done in WIRA car cabin, the fan of the car drove the flow through the front diffuser in three levels: high, medium and low flow rates equal to 0.0587 kg/s , 0.0443 kg/s and, 0.0293 kg/s, respectively. The experimental data was used to verify the simulation results. Three-dimensional CFD using FLUENT 6.3 showed that the optimal detector location was found to be in the middle of ceiling where the detector can measure the highest CO in the least amount of time and for easy maintenance.

Abstrak tesis dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PENENTUAN LOKASI OPTIMUM UNTUK PENGESAN KARBON MONOKSIDA DI DALAM KABIN KABIN KERETA

Oleh

HAMIDREZA GHEZAVATI

Jun 2011

Pengerusi: Profesor Madya Ir Nor Mariah bt. Adam, PhD

Fakulti: Kejuruteraan

Kajian tentang kepekatan karbon monoxida (CO) di dalam kabin kereta adalah sangat terhad di Malaysia. Objektif spesifik kajian merangkumi: (i) Penentuan laluan masukan CO ke dalam kereta sedang berhenti (ii) Kemasukan CO semasa kereta bergerak di jalan sesak, lalulintas, kurang sesak dan tiada kesesakan lalulintas (iii) keputusan dari objektif (i) dan (ii) digunakan sebagai parameter input untuk kerja simulasi menggunakan dinamik bendalir berkomputeran (CFD). Kereta juga dipandu dengan mod penghawa dingin kitaran semula dan mod masukan udara segar pada waktu pagi dan petang dari bulan September hingga Disember 2008. Kerja simulasi CFD adalah menggunakan model *realizable* k-ε untuk meramal lokasi optimum pengesan CO di dalam kabin kereta. Keputusan simulasi disahihkan dengan keputusan data eksperimen literatur. Model k-ε merupakan model keadaan bergelora yang sering digunakan kerana kejituannya untuk keadaan demikian.

Lebih 84 peratus masukan CO ke dalam kabin kereta adalah melalui ruang di dalam tempat penyimpanan belakang dan masukan sistem penghawa dingin iaitu 16

peratus melalui celahan, retak, lubang, rekahan atau lain-lain ruang di kabin kereta. Pendedahan CO yang paling tinggi disukat adalah pada mod kitaran semula di Jalan Lingkaran Tengah II (MRRII), pada waktu pagi dan petang dengan min CO masing-masing 19.7 ppm dan 18.5 ppm untuk 70 kali laluan. Pengukuran eksperimen untuk nilai CO yang dijalankan di kereta Wira melibatkan kipas mendorong aliran udara masukan pada mod tinggi, sederhana dan rendah masing-masing bernilai 0.0587 kg/s, 0.0443 kg/s and, 0.0293 kg/s. Data daripada eksperimen mensahihkan keputusan simulasi. Hasil keputusan CFD FLUENT 6.3 tiga dimensi menunjukkan lokasi optimum pengesan adalah di tengah-tengah siling kabin kereta yang mana tahap maksimum CO sering berlaku, memudahkan bacaan pengesan dan mudah menjalankan kerja penyenggaraan.

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I certify that an Examination Committee has met on 28 June 2011 to conduct the final examination of Hamid Reza Ghezavati on his thesis entitled "DETERMINATION OF OPTIMUM FOR CARBON MONOXIDE DETECTOR IN CAR CABIN " in accordance with the University colleges Act 1971 and the Constitution of Universiti Putra Malaysia [P.U. (A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree Doctor of Philosophy.

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DECLARATION

I declare that the thesis is my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

HAMIDREZA GHEZAVATI

Date:

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