Proceedings of the 9th World Congress on Momentum, Heat and Mass Transfer (MHMT 2024)
London, United Kingdom – April 11 – 13, 2024
Paper No. CSP 113
DOI: 10.11159/csp24.113

Research on the Pressure Release Characteristics of Gas Explosion Shock Waves by Air Doors

Xue-bo Zhang
College of Safety Science and Engineering, Henan Polytechnic University, Jiaozuo, China
zhxb@hpu.edu.cn

Extended Abstract

Ventilation door are commonly found in tunnels and other underground engineering ventilation structures, disaster periods using its explosion isolation, explosion relief, wind regulation characteristics for disaster prevention and mitigation is of great significance.This paper numerically simulates the propagation characteristics of the gas explosion shock wave in the nearby tunnel when the ventilation door are opened at different degrees, and analyzes the influence mechanism of the opening degree on the change law of the shock wave overpressure distribution in the nearby tunnel.The results show that the shock wave forms a strong turbulence area (high pressure area) on both sides in front of the ventilation door, and the area range and the overpressure value decrease with the increase of the opening degree; the ventilation door reduce the intensity of the shock wave, so that the overpressure behind the ventilation door decreases, and the smaller the opening degree, the lower the overpressure behind the ventilation door.The secondary explosion formed shock wave and the ventilation door reflected shock wave meet to form a stronger shock wave, which leads to different opening degrees of ventilation door, its before, after the roadway and after the bifurcation of the main roadway in the measured points of the overpressure change curve is different, the main difference is that the peak overpressure for the first wave or the second wave peak. The peak overpressure in the tunnel before and after the ventilation door decreases and increases respectively with the increase of the opening length, and the overall decay of the peak overpressure at 5m and 10m before the ventilation door is 49.56% and 4.04% respectively and only has an effect on the peak overpressure in main tunnel within 20m from the bifurcation.

***Keywords*:** ventilation door; gas explosion; numerical simulation; opening degree; overpressure peak;

References

[1] Wentao Yin,Gui Fu,Chun Yang, Zhongan Jiang , Kai Zhu, Yan Gao .2017.Fatal gas explosion accidents on Chinese coal mines and the characteristics of unsafe behaviors: 2000–2014. J. Saf Sci. 92:173-179. https://doi.org/10.1016/j.ssci.2016.09.018.

[2] Zhen He, Qiong Wu, Lijie Wen, Gui Fu.2019.A process mining approach to improve emergency rescue processes of fatal gas explosion accidents in Chinese coal mines. J. Saf Sci. 111: 154-166. https://doi.org/10.1080/19475705.2018.1541826.

[3] D. A. Kessler, V. N. Gamezo, and E. S. Oran, 2010.Simulations of flame acceleration and deflagration-to-detonation transitions in methane-air systems, Combust Flame,157(11):2063–2077.https://doi.org/10.1016/j.combustflame. **2010. 04.011.**

[4] Emmanuel Kwasi Addai, Dieter Gabel, Ulrich Krause. 2017. Lower explosion limit/minimum explosible concentration testing for hybrid mixtures in the Godbert-Greenwald furnace. Proc Safety Prog. 36(1):81–94.https://doi.org/10.1002/prs.11825

[5] Erhan Atay, Habibe Ilhan， Serkan Bayraktaroglu. 2020.The Turkish Soma Coal mining disaster: antecedents, consequences, and ethics Habibe Ilhan .J Business Ethics Educ, 16(13): 231-246. https://doi.org/10.5840/jbee20191613

[6] Xianfei Meng, Quanlong Liu, Xixi Luo, Xiaoxiang Zhou. 2019,Risk assessment of the unsafe behaviours of humans in fatal gas explosion accidents in China underground coal mines.J Cleaner Pro, 210(10): 970-976.https://doi.org/10.1016/j.jclepro.2018.11. 067.

[7] Runzhi Li,Rongjun Si,Lei Wang.2020. Propagation of gas explosions of different volumes in a large test tunnel, J.Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, https://doi.org/10.1080/15567036.2020.1851318
[8] Mohammed J. Ajrash, Jafar Zanganeh, Behdad Moghtaderi, 2017. Deflagration of premixed methane–air in a large scale detonation tube.J. Process Saf. Environ. 109: 374–386. https://doi.org/10.1016/j.psep.2017.03.035.
[9] Liutao Sun, Bingyou Jiang, Fanjun Gu, 2015.Effects of changes in pipe cross-section on the explosion-proof distance and the propagation characteristics of gas explosions. J Nat Gas Sci Eng, 25: 236-241. https://doi.org/10.1016/j.jngse.2015.05.007
[10] Robert Blanchard, Detlef Arndt, Rainer Grätz, Marco Poli, Swen Scheider.2010. Explosions in closed pipes containing baffles and 90 degree bends. J Loss Prevent Process Indus.23(2):253-259. https://doi.org/10.1016/j.jlp.2009.09.004.
[11] Edwards DH, Fearnley P, Nettleton MA. 2006.Shock diffraction in channels with 90 degree bends. J Fluid Mech. 132:257-270. https://doi.org/10.1017/S0022112083001597.
[12] Huahua Xiao, Qiangling Duan, Lin Jiang, Xuechao He, Jinhua Sun. 2015.Effect of bend on premixed flame dynamics in a closed duct. J.Int J Heat Mass Tran. 88:297-305.https://doi.org/10.1016/j.ijheatmasstransfer.2015.04.078
[13] Huahua Xiao, Xuechao He, Qingsong Wang, Jinhua Sun. 2013.Experimental and numerical study of premixed flame propagation in a closed duct with a 90°curved section. J.Int J Heat Mass Tran. .66:818-822 https://doi.org/10.1016/j.ijheatmasstransfer.2013.07.091.
[14] Lei Wang, Rongjun Si, Runzhi Li, Yan Huo. 2018. Experimental investigation of the propagation of deflagration flames in a horizontal underground channel containing obstacles.J.Tunn Undrgr Sp Tech 78:201–14. https://doi.org/10.1016/j.tust.2018.04.027.
[15] Na'inna, A. M., H. N. Phylaktou, and G. E. Andrews. 2017. Explosion flame acceleration over obstacles:effects of separation distance for a range of scales.J.Process Sat Environ 107:309–16. doi:10.1016/j.psep.2017.01.019.
[16] Minggao Yu, Shaojie Wan, Kai Zheng, Pinkun Guo, Tingxiang Chu, Chunyan Wang . 2018. Effect of side venting areas on the methane/air explosion characteristics in a pipeline. J Loss Prev Process Ind. 54:123–130.https://doi.org/10.1016/j.jlp.2018.03.010
[17] Jin Guo, Changjian Wang, Xuanya Liu, Ye Chen. 2016. Explosion venting of rich hydrogen-air mixtures in a small cylindrical vessel with two symmetrical vents. J.Int. J. Hydrogen Energy 42 (11), 7644–7650.https://doi.org/10.1016/j.ijhydene.2016.05.097.
[18] Ye Chen, Yi Li, Ziting Li, Chao Ji, Xuanya Liu. Effect of vent area, vent location and number of vents on vented hydrogen deflagrations in a 27 m3 chamber. J.Int. J. Hydrogen Energy 45 (55), 31268–31277.https://doi.org/10.1016/j.ijhydene.2020.08.032.
[19] Xiepeng Sun, Longhua Hu, Yong Yang, Fei Ren, Xiang Fang. Evolutions of gas temperature inside fire compartment and external facade flame height with a casement window. J. J Hazard Mater, 381: 120913.https://doi.org/10.1016/j.jhazmat.2019.120913.
[20] Yimeng Zhao,Jiansong Wu,Rui Zhou.Effects of the length and pressure relief conditions on propagation characteristics of natural gas explosion in utility tunnels.J Loss Prev Process Ind., 75:104679. https://doi.org/104679.10.1016/j.jlp.2021.104679
[21] Kai Wang,Haiqing Hao,Shuguang Jiang,Weiyao Cai,Yuchen Zhang,Ziting Wang. 2020. Experimental study on the characteristics of overpressure wave to ventilation facilities during gas explosion and automatic shock relief devices. Geomat Nat Haz Risk, 11(1): 2361-2384. https://doi.org/10.1080/19475705.2020.1836039.
[22] Yashengnan Sun,Xihua Zhou, Gang Bai,Ang Li,Tianyu Xin,Dongfang Li, 2021. Vent burst doors as an effective method of suppressing the dangers of gas explosions. AIP Adv, 11(3): 035112.https://doi.org/10.1063/5.0033835.
[23] Xuebo Zhang, Jianlian Gao, Shuaishuai Shen, Jingzhang Ren, Rongkun Pan,Chunxia Wang.2021.Numerical simulation of shock wave propagation law in large-scale mine J.Journal of China University of Mining & Technology,2021,50(4):676-684.https://doi.org/10.13247/j.cnki.jcumt.001311.
[24] Xuebo Zhang,Jianliang Gao,Jingzhang Ren,and,Chunxia Wang. Analysis of the Characteristics and Influencing Factors of Gas Explosion in Heading Face. J.Shock Vib. 2020 (8871865) https://doi.org/10.1155/2020/8871865.
[25] Xuebo Zhang, Shuaishuai Shen, Ming Yang, Hao Wang , Jing-zhang Ren, Fang-chao Lu . Influence of length and angle of bifurcated tunnel on shock wave propagation. J Loss Prev Process Ind..78:104802. https://doi.org/10.1016/j.jlp.2022.104802.

[26] Xuebo Zhang, Shuaishuai Shenm, Zhiyang Gao.Research on the Decompression Effects of Shaft Explosion-Proof Door at Different Lifting Heights. J.Shock Vib. 2021 (2115767).https://doi.org/10.1155/2021/2115767.